GUIDELINES FOR USING SOIL TAXONOMY IN THE NAMES OF SOIL MAP UNITS

edited by
A. Van Wambeke
T. Forbes

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New York State College of Agriculture and Life Sciences
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Department of Agronomy

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A. Van Wambeke[1]
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1. Professor of Soil Science and Senior Research Associate, Department of Agronomy, New York State College of Agriculture and Life Sciences, Cornell University, Ithaca, N.Y. 14853.

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Foreword

Soil resource inventories are the basis for agrotechnology transfer and for national or regional planning. It is highly desireable that soil resource inventories communicate soils information through a common international system. *Soil Taxonomy* is such a system. This monograph attempts to explain how soil map units may be named using *Soil Taxonomy* as an international reference system.

In many developing countries guidelines for naming soil map units are not available. This monograph provides useful information on naming soil map units. Using *Soil Taxonomy* will provide a strong basis for transferring information from soils in other parts of the world where important research results are available.

This monograph was produced by the Agronomy Department of Cornell University with funding from SMSS. It is one of a series of monographs by SMSS on *Soil Taxonomy* and soil resource inventories.

Hari Eswaran
Program Leader SMSS
May, 1986

Preface

Soil scientists, like other scientists, strive to recognize and understand the truths about soils in nature. To the degree that we are able to recognize and understand those truths, we also want to be able to communicate our perceptions and understandings of soils with others. That is what soil classification and soil maps are all about.

Soil classification is a method of organizing and communicating our knowledge and perceptions about the attributes of soils; soil maps provide a method for communicating what we know about the distribution of soil attributes in nature - i.e. soil geography. The document that follows presents guidelines and conventions used to make our perceptions and communications consistent among soil scientists.

Before proceeding with these guidelines and conventions, however, we should all understand that the only absolute truths about soils are to be found *only* in the soils themselves in nature. We observe and measure the attributes of soil in the field and in samples we bring into the laboratory as accurately as we can, but our observations and measurements are only approximations of the truths that exist in nature - perhaps very good approximations but, nevertheless, not absolute truths. We note that the soil at any given spot of a size such that we can observe and measure soil attributes has a set of properties which, in the aggregate, we can use to describe the soil. We also note that, although these sets of properties vary from place to place in nature, some are much alike and much different from others. To make our job easier, therefore, we *think* about all of those which are alike as one *kind* of soil - we classify soils, and we give our classes (taxa) names so we can communicate about them. These taxa or classes are not truths in and of themselves; they are our best *approximations* of what we perceive as truths.

Having classified soils, we want to be able to tell others how bodies of these soil classes or taxa are distributed in nature. So we make soil maps on which we attempt to draw boundaries that enclose areas representing natural soil bodies that we can describe in terms of soil classes or taxa. Again, we can only approximate a mappable soil body that corresponds with a soil class or taxa. We draw boundaries around areas on our map on the basis of clues we can see in the landscape and our observations of internal soil properties at sites that are samples of real soil bodies. Our boundaries inevitably enclose more than one soil taxon or class; the soil bodies they represent are impure, but they are our best approximations of truth in nature.

The foregoing are fundamental precepts which every soil scientist should understand. We deal in approximations, not absolute truths, but our efforts produce useful tools for working with soils. The conventions and guidelines for our work have been compiled with these facts in mind to provide for consistency in dealing with a very complex natural phenomenon.

M.G. Cline
Ithaca, 1985

Introduction

The subject of this publication is the guidelines for proper use of taxonomic names in the naming of map units in soil resource inventories. These guidelines have been compiled from notes and documents prepared by the Soil Conservation Service of USDA, in activities related to the preparation of a revised *Soil Survey Manual*.

The main sources of information were: (1) *National Soils Handbook*, 430-VI Issue 1, July 1983 particularly part 602, "Soil classification", and (2) *Soil Survey Manual* (revised), 430-V, Issue 6, particularly "Examination and description of soils in the field" (Chapter 4, May 1981), "Map units" (Chapter 5, Sept. 11, 1980), and "The mapping legend" (Chapter 6, May 1981). Many parts have been taken verbatim from these sources.

Many terms such as pedon and others have been taken from *Soil Taxonomy*. We have not made an attempt to describe in detail all these terms. The reader should refer to *Soil Taxonomy* for these definitions.

The present guidelines have rearranged the subject matter and have incorporated new texts. The first chapter deals with definitions and concepts which are important for the understanding of maps and classifications. The second chapter explains the different reference systems which can be used for naming soils on soil resource inventory maps. The third chapter describes kinds of soil resource inventories and their appropriate map units. The fourth chapter gives the conventions and rules governing the structure of names in the English language, when applied to soil survey map legends.

Soil Taxonomy in this text is used as a reference system together with others. One of the others is the "kinds of map units" as they are described by the USDA Soil Conservation Service. Other map unit systems could be used and linked with *Soil Taxonomy* to form soil map legends. The present guidelines, which are intended to serve soil resource inventories in other countries, therefore, are only given as an example, not an authoritative text to guide operations in the United States.

There are a number of definitions which are not completely identical to those of the National Soils Handbook and Soil Survey Manual, and some new units and terms are proposed in these guidelines.

A supplementary slide set has been prepared to introduce this subject to an audience of soil scientists interested in soil geography (the text of the slide set is in Appendix C). The slide set emphasizes the concepts and the rationale of the conventions, but it is incomplete and somewhat more flexible in its presentation than the actual guidelines.

The guidelines do not explain how to construct a soil map legend. They only deal with the ***naming of the map units****, once the framework of the legend has been established.*

We thank Dr. S. Buol and Dr. M. Cline for comments they have made on preliminary drafts. Soil Conservation Service staff reviewed the parts dealing with the *National Soils Handbook*. We gratefully acknowledge the contributions of Drs. R. Grossman, R.F. Harner, G. Holmgren, C.S. Holzhey, J. Kimble, K.H. Langlois, J.D. Nichols, J. Witty and other SCS personnel.

CHAPTER 1

What's in a Map

1.1 Map Units

Soil boundaries are shown on maps by *lines*. The lines separate segments on the map. The segments represent soil bodies as they are recognized in the field. Each area which is completely circumscribed by a soil boundary on a map is called a "*soil delineation*".

A soil "*map unit*" consists of the aggregate of all soil delineations which are identified by a unique symbol, color, name or other representation on a map. All soil delineations which are identified the same way constitute a map unit.

Soil maps almost always contain more than one map unit. These units can be arranged in many ways. Any organized list of map units may be called a "*legend*" (Figure 1.1). There are several kinds of legends. Map units have symbols and names. The rules of nomenclature may differ from one legend to another. It is important to know the origin of the names. One source of names may be a soil classification system. This paper is concerned primarily with map unit names derived from soil classification.

1.2 Taxonomic Units Versus Map Units

In science some classifications are called taxonomies which define *taxonomic units*. Although taxonomic units in soil resource inventories focus on the same objects (soils) as do map units, the two units are different concepts and are useful for different interests aiming at common objectives.

Taxonomic units, or classes, can and often are created without concern for the real world. It is possible, for example, to conceive a class grouping all soils which have grey colors in the subsoil. This grouping may or may not be required to be delineated on maps. The classifier has thus created an abstract concept which accepts as members all soils having a selected property. The grey color class would be a *taxon* in a taxonomic system and as such a subdivision of the soil "universe" (Figure 1.2). The name of the subdivision would designate all soils which have the characteristics listed in the definition. Many times names given to soils refer to taxonomic classifications based on soil properties. Another example of this would be "red soils".

It is almost never feasible to delineate accurately on a map the area that soils of one taxonomic class occupy in the field. A simple explanation for this is that nobody really maps soils by taxonomic units. All soils are hidden below the surface. Only their surface configuration and surface properties are visible. It is not feasible to follow on the ground the actual boundary of the properties that are only present in the subsoil. There is presently no way to draw a soil map as a portrait of an object which can be directly observed. Neither is it presently possible to make a photographic image of all taxonomic units which make up a landscape. Soil mappers have to rely on outside indicators such as topography, vegetation, surface colors and other properties to draw lines on a map. The degree of coincidence between the delineated area and the actual soil properties depends on the reliability of the outside indicators and many other things. The mapper checks his field assumptions by augerings and profile pits, which are usually widely spaced one from another.

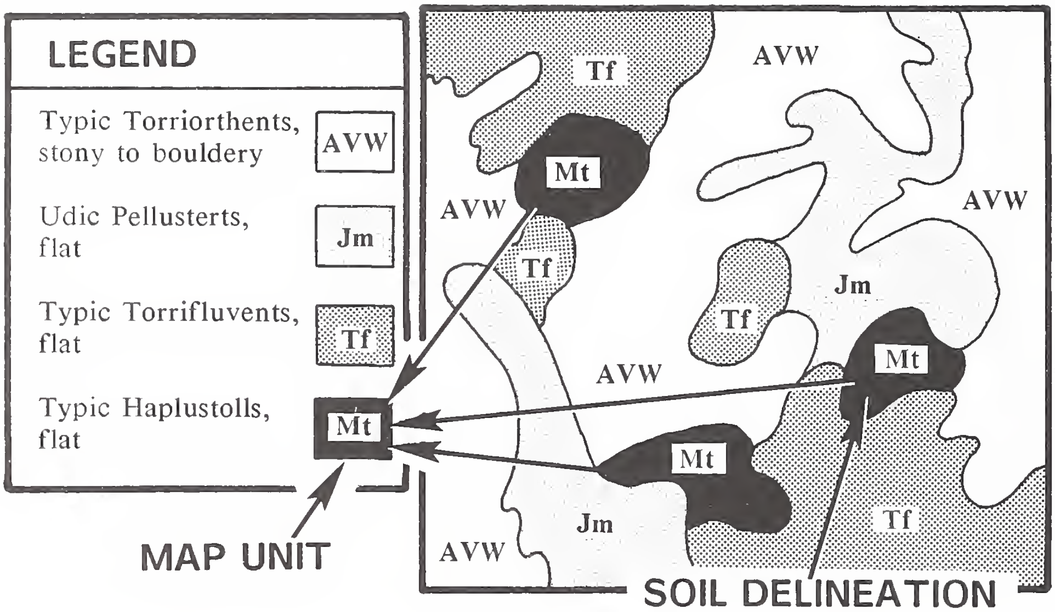

Figure 1.1: Components of a soil map.

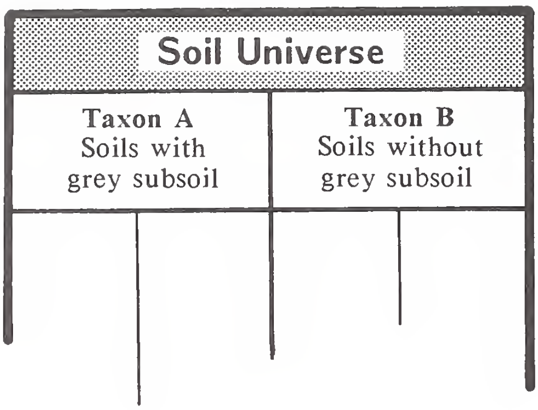

Figure 1.2: A taxonomy is used to divide the soil universe into taxa.

There are other reasons for discrepancies between mapping and taxonomic units. Some soils belonging to different taxonomic units are so intimately intermingled or occupy areas so small that they cannot be shown separately on maps at any practical scale. Any single delineation usually represents an area of soils which belong to two or more taxonomic units.

Soil Taxonomy is not the only system which provides map unit names. For example "phases", in USDA soil survey conventions, are subdivisions of taxa that are created outside *Soil Taxonomy* and are recognized to make the soil map more useful to land users.

Soil taxonomic units and map units are two distinct and different entities. Taxonomic units define specific ranges of soil properties in relationship to the total range of properties measured in the soil. Soil map units, and their individual map unit delineations define areas on a landscape (Figure 1.3). Taxonomic names are used to identify the soil properties most prevalent within the pieces of landscape identified as a map unit. Almost every map unit has more than one taxonomic unit included. The guidelines for proper use of taxonomic names in the naming of map units in soil resource inventories is the subject of this publication.

In summary, the fundamental difference between taxonomic units and map units is that the first is a concept resulting from subdividing the soil universe, while map units

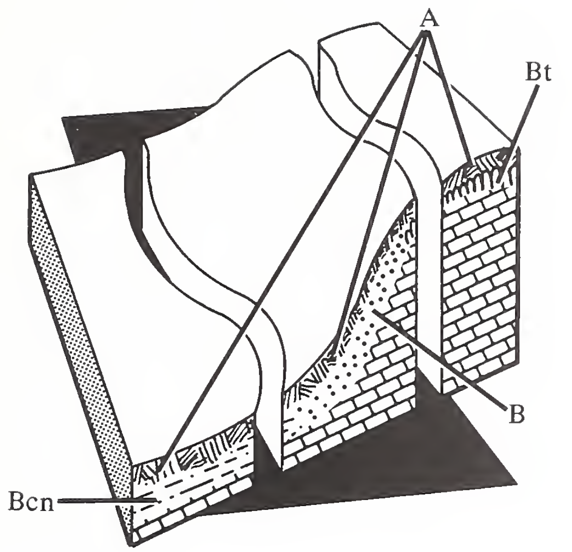

Figure 1.3: The surface features of a landscape help to define soil map units.

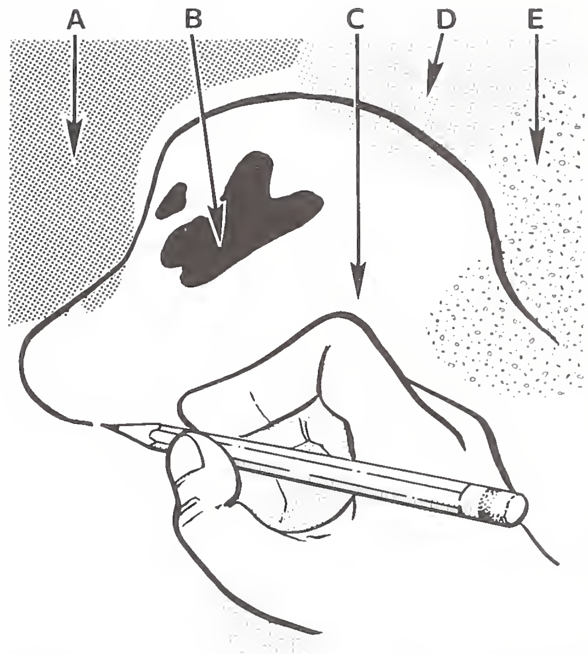

Figure 1.4: Soils included in a map delineation seldom all belong to one taxonomic unit.

result from the grouping of soil delineations which have the same name, symbol, color or other representation.

1.3 Mapping Inclusions and How to Minimize Them

The taxa and the names recognized in *Soil Taxonomy* carry strict definitions. However, not all the soils occurring in a map delineation belong to the taxonomic class or classes used to name the map unit. The soils which fall outside the defined taxonomic range constitute "mapping inclusions" (Figure 1.4). They are also sometimes called impurities. There are different kinds of mapping inclusions.

Inclusions dilute the homogeneity of map units. The importance of inclusions, in terms of the area they cover, and their contrasting properties should not be to such a degree that they would significantly affect the interpretations one would make on the basis of the properties of the soils used to name the map unit. Ideally one would like to define and name map units such that the units would contain the smallest amounts of inclusions that practical mapping techniques would permit. There are several ways to achieve this.

If delineations contain more than one kind of soil, each affecting use or management differently, the map units are designated by the names of their constituent soils. In this case the amount of unnamed inclusions is reduced by increasing the number of components named in the map unit, without changing the definitions of the components themselves.

In another case where constituent soils have similar potentials for use and similar management requirements, the map unit may be named for the dominant kind of soil with the other described in the map unit description in the report. In this way the number of named soils in the map unit name is reduced without significantly decreasing its practical information content.

A third way to minimize inclusions of a map unit is to raise the categorical level of the taxonomic unit, thus encompassing a wider range of soils. This method however will not always produce the expected results.

Some inclusions may originate from other sources. *Soil Taxonomy* does not provide a place for all soils at the subgroup level and below. It is only comprehensive for soils which have been recognized to exist. These unnamed soils are not provided for at

the subgroup, family or series levels. These soils form some of the impurities of map units. The decision to "establish" them as new taxa depends on their degree of similarity with classified soils and their extent.

For all the above reasons, visualizing degrees of differences among soils is very important. If differences do not affect use and management, the soils are compared as *similar soils*. If differences do affect use and management, the soils are contrasted as *dissimilar soils*.

The need to distinguish degrees of similarity can be best explained with examples. One relates to classification, and the decisions to establish new taxa. For a given soil resource inventory, or in a given country, no useful purpose is served to create new subgroups with subsequent proliferation of new families and series, if the basis for differentiation is only a small departure from a class definition which never reaches the central concept of a competing taxon in the area under study and is of limited extent.

Another example concerns land use and the presence of attributes which restrict crop growth. The presence of a severely limiting property in a part of a group of soils which all belong to the same taxon, should be a reason to distinguish that part as a separate map unit. The decision to do so will depend on the degree of similarity, based on the severity of the limitation and the ability to delineate the soils as a separate map unit.

Guidelines for estimating the degree of similarity among soils are given in the subsections that follow.

1.3.1 Similar Soils

Similar soils are alike in most properties which are used as criteria to distinguish them at the categorical level of the taxon which names them *and those categorical levels above*. They share the limits of the diagnostic properties in which they differ or differ only slightly from them. Their differences are small both in number and in degree. Most similar soils differ in no more than two or three criteria that differentiate them. Interpretations for the most common uses of these soils, considered as a group, are alike.

Some examples follow: phases of the same soil series that share limits of most phase criteria within the range of properties in a soil series are considered similar soils. The 4 to 8 percent and 8 to 12 percent slope phases of the same series share a limit at 8 percent slope gradient. The range of slope gradient of each is relatively narrow. Other soil properties are alike. The two soils are *similar phases* of the same soil series.

Similar phases of two soil series are also considered *similar* taxa if the two series: (1) differ in only one or two diagnostic properties and (2) share the limits of the diagnostic properties that distinguish them. For example, soils which belong to two soil series that are members of the same family, share *all* the diagnostic properties of *all* categories above the soil series. If the properties of two series merge at the limit between series criteria which separate them, then the soils are similar soils, even on maps which distinguish soils at the series level.

The properties which may differ slightly from the definition of a given taxon include all differentiating characteristics used at the categorical level of the taxon *and those categorical levels above*. The example that follows illustrates a pair of similar series differentiated at the level of soil orders. Both are members of fine-loamy, mixed, mesic families. Both have argillic horizons and similar sequences of horizons. The first is a Typic Argiaquoll and the second is a Udollic Ochraqualf. The name, Udollic Ochraqualf signifies that the Alfisol approaches but does not equal the Typic Argiaquoll in the thickness of its dark-colored epipedon and in criteria of wetness. The differences in their epipedons place the two series in different orders, but all other properties merge or share common boundaries below the order level. The two soils share limits of major diagnostic criteria but are otherwise much alike. In mapping legends which use taxa at the series level, the two soils may be considered similar.

Soils of one taxon are not necessarily similar. For example a given soil series may contain dissimilar phases. In classes of higher categories the name of a taxon implies a restricted range only in the properties which were selected as differentiating characteristics. All the other properties may vary widely and include very dissimilar soils.

A soil which is said to be similar to a given taxon, for example a subgroup, differs only in a few characteristics definitive for that taxon at the given level *and above*. It may however vary widely in many

characteristics at lower levels and include many dissimilar soils. A special kind of similarity is discussed in the following section.

1.3.1.1 Taxadjuncts

Some kinds of soil differ from established soil series only to a minor degree in one or two properties. The following example is typical. A soil series that is defined as a member of a thermic family may be identified and mapped over an extensive area where soils have thermic temperature regimes. Near the geographic limit between thermic and mesic soil temperature regimes, a soil may be similar in all respects except that it has a mesic temperature regime no more than two or three degrees cooler than the limit of the thermic regime. Such a soil is outside the range of the established series, but it differs only to a small amount in a single property. If no similar soil series having a mesic soil temperature has been established, the soil may be considered a *taxadjunct*. It is identified by the name of the established series *without qualification*. The departure from the soil temperature limit is described in the text of the published soil resource inventory, perhaps as a footnote. The soil is an adjunct to but not part of the named series. It is treated as a member of the map unit which carries the name of the series in the legend and in interpretations, but not as a member of the "taxonomic" series.

The current *Soil Taxonomy* sets quantitative limits of many soil properties for taxa. When these limits were applied to soil landscapes, they cut off pieces of landscape that were formerly treated as parts of an established taxon. Some of these "splinters" became parts of new or redefined soil series. Others remain unclassified at the series level in the current taxonomy. Those that are not classified and that represent only a small fraction of the range of a *set* of properties unique to a taxon are taxadjuncts.

A soil is said to be a *taxadjunct* when it cannot be classified at the level under consideration; it differs only slightly from the taxonomic definition of existing taxa, and it has the same interpretations as the named taxon.

1.3.2 Dissimilar Soils

Soils which are not similar, are dissimilar. There is nothing in between. The differences among dissimilar soils are either large in number or in degree, or both. The differences may be in properties that are diagnostic for phases, series, families, or taxa of higher categories, or in combinations of properties that are diagnostic at different categorical levels.

Dissimilar soils, considered separately, usually merit different predictions about their potentials for some important uses, the management inputs they need for effective use, or their behavior under various uses. When one of a pair of dissimilar soils only covers small areas in a map unit dominated by the other, predictions for the map unit are not necessarily affected significantly. If such an inclusion does not *restrict* the use of entire areas or impose *limitations* on the feasibility of management practices on them, its impact on predictions for the map unit may be small.

If dissimilar soils occupy areas large enough to modify the use of the map unit, the name of the map unit should allow the reader to identify this limitation (see Chapter 2).

Some differences between soils may be important to mention in map unit names because they restrict land use significantly. Others, on the contrary, may not affect the interpretations. This consideration is the basis for distinguishing the following concepts.

1.3.2.1 Nonlimiting Inclusions

Inclusions of soils having less severe restrictions to use than the dominant soil of a map unit may not affect most predictions about the unit as a whole. Such inclusions can be described as a *nonlimiting inclusions*.

1.3.2.2 Limiting Inclusions

If an inclusion has significantly more severe restrictions for use than the dominant

soil, or affects the feasibility of meeting management needs, a small amount in a map unit can greatly affect predictions. These are the most critical inclusions. They are considered *limiting inclusions.*

1.3.2.3 Variants

Certain soils differ from established soil series in properties important for land-use. In present USDA Soil Conservation Service thinking, if these soils occupy small aggregate areas, i.e. if their total extent is less than about 800 ha, they are usually considered as *variants* of an existing soil series. Names of variants can be used to designate map units or one of their components, without the need to establish a series, or other taxon, in *Soil Taxonomy.*

CHAPTER 2
What's in a Name

2.1 Names as Reference Terms

Map units or groups of map units can be given any name derived from any discipline. One may call a map unit "alluvial soils", "mountain soils", or "savannah soils". Or one could be more specific and refer to *Soil Taxonomy*, using the names provided by that system. For example the name Udoll could be used to identify a map unit consisting of soils of the Udoll suborder. *Any name given to a map unit always refers to a classification.* "Wet soils" refers to a system which distinguishes "wet soils" from "dry soils". Names are no more than labels given to objects or concepts which relate them to properties associated with the given name. An object may have two names, each of which refers to a different classification, just as an object may be called differently in two languages. A classification is in fact no more than a technical language where each name carries a definition.

Taxonomy is a narrower term than classification. It is the part of classification that is concerned primarily with relationships (Soil Survey Staff, 1975).

2.2 Language Requirements

When constructing identification legends, one should remember that technical terms will be combined into descriptive sentences, which must conform with the grammar of the language in which the soil resource inventory and legend are written. The function that a legend serves is to convey information to users, and this information should be presented in the language and style most acceptable to them.

These guidelines address problems encountered in the preparation of soil legends written in English. Certain rules on syntax and punctuation are given. The purpose is to achieve some uniformity among soil resource inventories. These rules are only valid for the English language, and will need revision when introduced in other tongues.

Common languages do not always consistently follow a clear logic in the construction of their descriptive sentences. Traditional usages of word sequences may differ significantly from current usage. Therefore the methodology which is described here is not always consistent throughout.

2.3 Reference Systems

An important purpose of these guidelines is to demonstrate how the names of taxa in *Soil Taxonomy* can be used to name map units. *Soil Taxonomy* is not the only system which can be used. Soil legends may use other systems. Some of these other systems provide terms to designate the *components* of map units. Others provide names for *attributes* of components, qualities of map units, land areas, landscapes, etc. The terms are then used to qualify the objects, or indicate the properties shared by a group of objects. The following systems, along with *Soil Taxonomy*, provide names for map units:

1. *Kinds of map units* inform about the complexity and relationships between the components of the map unit. Examples of kinds of map units would be consociations, complexes, and associations. As pointed out in the introduction, the system described here is the one commonly used in the United States by the Soil Conservation Service. Others could be proposed.

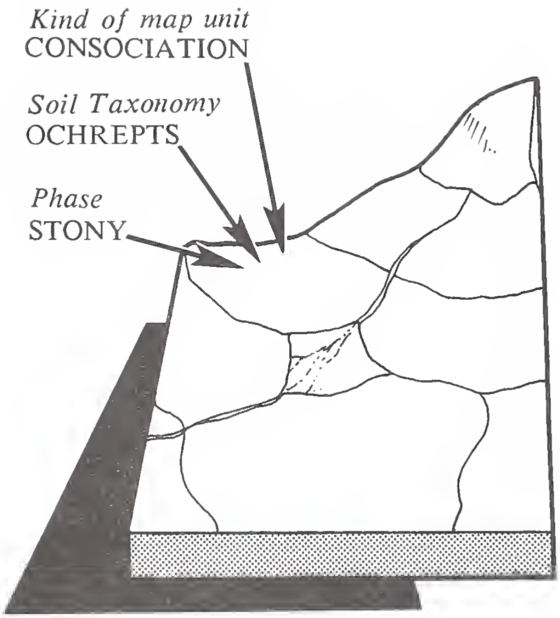

Figure 2.1: Different reference systems used to define a map unit.

Individual countries could construct others.

2. *Soil Taxonomy* itself not only provides names of taxa, but also qualifying terms to be used as adjectives. An example of the first is "Haplorthox - Dystropepts Association"; an example of the second is "Torriorthents, isomesic".

3. *Phase* and *area* distinctions.

4. Kinds of *miscellaneous areas* which are used to name areas dominated by non-soil.

5. Names of *other* reference systems such as physiographic units, agro-ecological zones, interpretative groupings, etc.

These different reference systems are independent, but when combined into a name of a map unit, they interact intimately (Figure 2.1).

2.4 Kinds of Map Units

A map unit may contain only one or several taxonomic components. There may be soils referred to by a taxonomic name, or there may be non-soil. The components may differ in size and shape of their areas, in degree of contrast, in geographic distribution, etc.

It is desirable that all map units be named with terms indicating the taxonomic classification of its soil components. In this way the maximum information contained in the classification is conveyed to the user of the soil resource inventory. The map units thus defined and named are aggregates of taxa, each of which may be qualified, for example by phase names.

On small-scale generalized soil maps this aggregation of taxa does not always produce satisfactory results. Some areas of map units have to be qualified by terms highlighting important properties shared by the whole area.

2.4.1 Primary Kinds of Map Units

Five primary kinds of map units are presently used in soil resource inventories to show map unit composition. All five contain, in addition to inclusions, components in which the soils belong to one single taxonomic unit or kind of miscellaneous area. The primary components of these kinds of map units are single taxa or miscellaneous areas, and as such they are called "primary kinds" of map units. The five kinds are: *consociations, complexes, associations, undifferentiated groups and unassociated soils*[1]. Other kinds could be devised.

Criteria that are used to distinguish kinds of map units are: (1) the number of taxonomic components, (2) their degree of similarity, (3) the scale at which they can be mapped separately, (4) the occurrence of each component in each delineation, (5) the percentage of limiting inclusions, (6) the regularity of distribution of the components.

These criteria are combined as a key in a following section (section 2.4.1.5). The key is meant to lead the reader through the decisions to choose the proper kind of map unit. It applies to the kinds of map units which are based in the grouping of taxa as defined by *Soil Taxonomy*. The key is meant

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1. "Unassociated soils" is a kind of map unit not presently used in the United States.

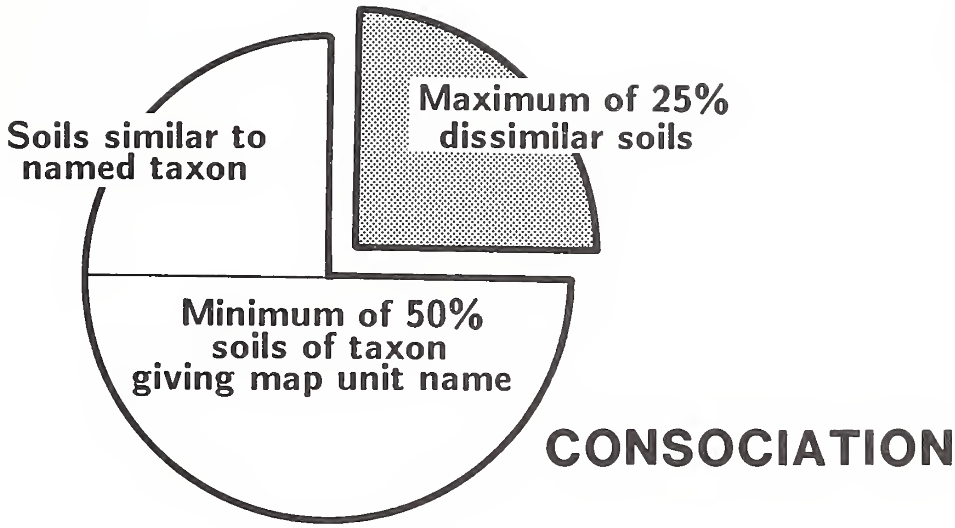

Figure 2.2: Composition of a consociation.

to be used repetitively, starting with the most detailed (lowest level) taxonomic definitions of the components.

Kinds of map units closely depend on the level of the taxonomic classification used to designate their components. For example, an area covered completely by Oxisols could be described as a consociation of one soil order. At a larger map scale it may be identified as an association of great groups, or other lower level taxa.

2.4.1.1 Consociations

In a consociation, delineated areas are dominated by a single soil taxon (or miscellaneous area) and similar soils. As a rule, at least one half of the pedons in each delineation of a soil consociation are of the same taxonomic unit and provide the name for the map unit[2]. Most of the remainder of the delineation consists of taxonomic units so similar to the named soil that major interpretations commensurate with the categorical level of the taxon are not affected significantly. The total amount of dissimilar inclusions of other components in a map unit generally does not exceed about 15 percent if limiting and 25 percent if nonlimiting with a single component of dissimilar limiting inclusions generally not exceeding 10 percent if very contrasting. The amount of dissimilar inclusions in an individual delineation of a map unit can be greater than this if no useful purpose would be served by defining a new map unit. The soil in a consociation may be identified at any taxonomic level (Figure 2.2).

Some examples of consociations are: Alderwood gravelly loam, 0 to 3 percent slopes; Antilon gravelly silt loam, deep, 0 to 3 percent slopes; Badland; Houghton muck; Rock outcrop; Typic Fragiochrepts, rolling.

2.4.1.2 Complexes and Associations

Complexes and associations consist of two or more named *dissimilar* taxa or miscellaneous areas occurring in a *known and definable* pattern.

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2. Some soil consociations may be less than one half the named soil if most of the remainder of the map unit consists of two or more soils that are similar to the named soil. The unit is named for the dominant soil.

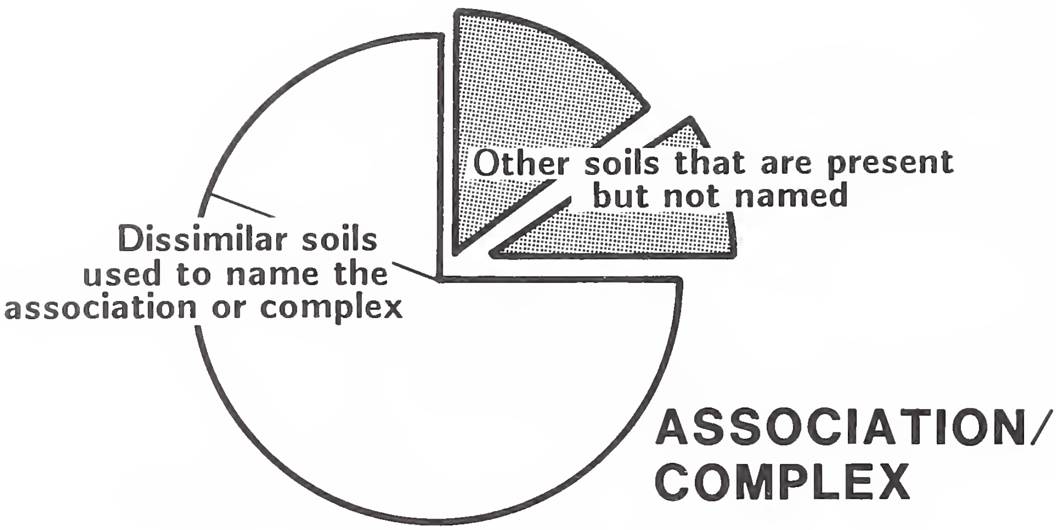

Figure 2.3: Composition of an association or complex.

Only the following arbitrary rule related to map scale determines whether the name complex or association be used: *the major components of a complex cannot be mapped separately at a scale of about 1:24,000*. At this scale an area of 0.4 cm^2 on the map represents an area of 2.3 ha on the ground. The named components of an association should be mappable at this scale. In either case, the major taxa components are sufficiently different in morphology or behavior that the map unit cannot be called a consociation or none of the taxonomic components with its taxadjuncts covers 50% or more of the area. As pointed out before, the kind of map unit depends on the taxonomic level used to designate the components of the map unit: e.g., an association of great soil groups on one map may be called a complex of soil series on another map (Figure 2.3).

In each delineation of either a complex or an association, *all* of the major components *are normally present*, though their *proportions may vary* appreciably from one delineation to another. The total amount of inclusions that are dissimilar to all of the major components does not exceed about 15 percent if limiting and 25 percent if nonlimiting.

Complexes or associations should be used in map legends if two or more distinctive kinds of soil, or kinds of miscellaneous areas are consistently associated in delineations. The geographic patterns and relative proportions of components implied by complexes and associations are important attributes for interpreting map units. The term "association" or "complex" tells a person who uses the soil map that both kinds of soil will be present in *each* delineation of the map unit. It also tells him that the two are associated in characteristic patterns and proportions, which are described for the map unit.

Complexes and associations may be qualified by terms describing characteristics of the entire area covered by the map unit.

2.4.1.3 Undifferentiated Groups

Undifferentiated groups consist of two or more named taxa that are *not consistently associated* geographically but that are included in the same map unit because use and management are the same or *very similar* for

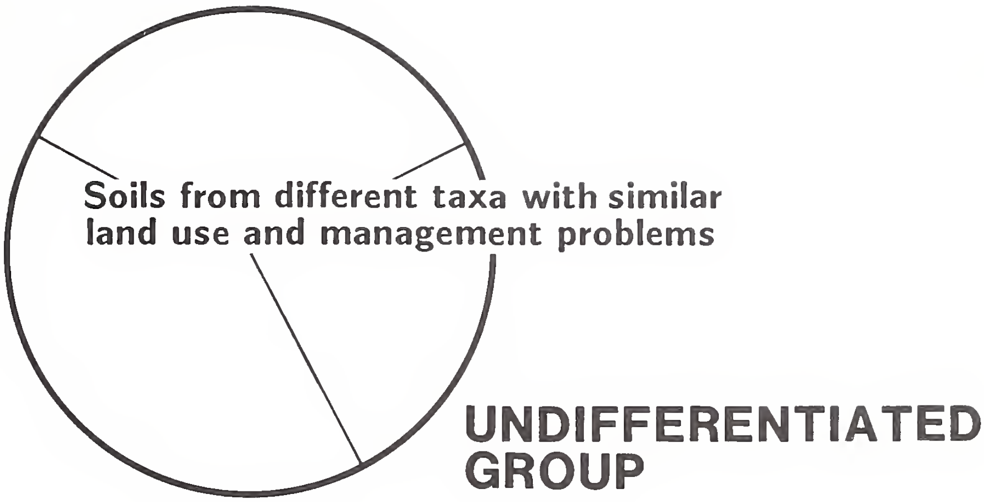

Figure 2.4: Composition of an undifferentiated group.

common uses. Generally they are included together because some common feature such as steepness, stoniness, or flooding determines limiting use and management.

One attribute is so overwhelmingly limiting that further subdivision of the unit is not considered necessary. For example, if two or more very steep soils geographically separated have almost the same potential for use and management that mapping them separately would serve no useful purpose, they may be placed in the same map unit. Every delineation has at least one of the major components and some may have all of them. The same principles regarding proportion of inclusions apply to undifferentiated groups as to complexes and associations (Figure 2.4).

2.4.1.4 Unassociated Groups

These are map units that contain two or more important kinds of soils that (1) have different suitabilities for use and (2) their distribution in the landscape is unknown.

They are used commonly on general soil maps at very small scales when areas of two contrasting soils must be included in the same delineation. In parts of Brazil, for example, Typic Haplorthox and Oxic Dystropepts must be included in the same delineations of small-scale maps, though they are not associated in a known pattern since their distribution in the landscape cannot be elucidated because a dense rainforest does not permit study of the topography. At larger scales, they would be identified as unique soils.

Such map units are named as unassociated groups to imply that it was not feasible to determine their pattern of association. The connecting word *or* is used in the name to imply that in any one part of a delineation it will be difficult to predict which component of the map unit will be found. The name *Typic Haplorthox or Oxic Dystropepts* is an example.

This kind of mapping unit is not used at present by the USDA Soil Conservation Service.

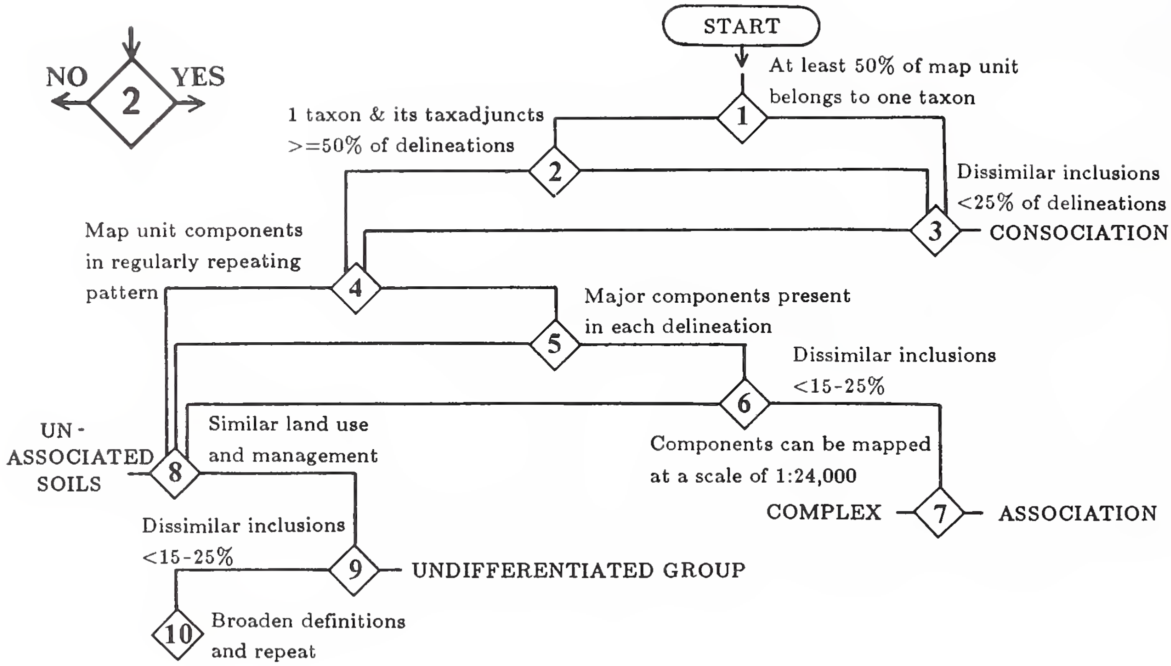

Figure 2.5: Flowchart for kinds of map units.

2.4.1.5 Key to Map Units

The following section is to be used starting at point *1* by checking the condition at that point for true or false. "False" in this key also includes "unknown" to deal with situations where the presence of required criteria cannot be assessed with certainty. Users of the key should follow the pathway indicated by the "go to" statements (see also Figure 2.5).

1. At least 50% of the area in each delineation of the map unit is covered by soils which belong to one taxon, or by one kind of miscellaneous area.

   if true, go to...3; if false, go to...2

2. Soils of one single taxon *and its taxadjuncts* occupy at least 50% of the area of each delineation.

   if true, go to...3; if false, go to...4

3. The total amount of dissimilar inclusions in most delineations does not exceed[3]

   10% if single contrasting inclusion and limiting
   15% if two or more limiting inclusions
   25% if nonlimiting

   if true: *Consociation*; if false, go to...4

4. The components of the map unit occur in a known and defined pattern in the landscape.

   if true, go to...5; if false, go to...8

5. All of the major components are normally present in each delineation.

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3. The Soil Conservation Service allows different amounts for different orders of soil surveys.

if true, go to...6; if false, go to...8

6. The total amount of inclusions that are dissimilar to all of the named components in the map unit does not exceed

   15% if limiting
   25% if non limiting

   if true, go to...7; if false, go to...8

7. The major components of the map unit can be mapped separately at scale of about 1:24,000.

   if true: *Soil Association;*
   if false: *Complex*

8. The use and management potential of the major components are essentially the same for common use.

   if true 9;
   if false: *Unassociated group*

9. The total amount of inclusions that are dissimilar to all of the named components in the map unit does not exceed

   15% if limiting
   25% if non limiting

   if true: *Undifferentiated group;*
   if false,...10

10. It is recommended to repeat the keying procedure from point *1*, broadening the definitions of the taxa, i.e. by using higher category taxa until a reasonably low number of determining taxonomic components can be identified. See also the next section (section 2.4.2).

2.4.2 Other Kinds of Map Units

Unassociated groups, and any undefined soil mixture may provide unsatisfactory names and definitions in some legends. It is then recommended to repeat the keying process outlined above using more general taxonomic classes to designate the components with a minimum loss of information.

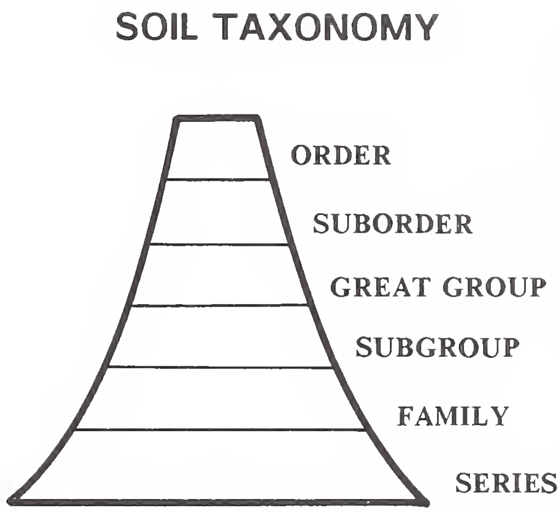

Figure 2.6: The hierarchy of Soil Taxonomy.

This can not always be satisfactorily achieved, however, and other devices have to be applied. One of them is to regroup composite units to form secondary map units. Just as single taxa may be grouped to form a single map unit, several composite units, such as associations, may be treated as one. An example is Undifferentiated Soil Associations (see section 4.3.1).

2.5 Soil Taxonomy - A Source of Map Unit Names

Soil Taxonomy (1975) and subsequent amendments (1983, 1985) are used in these guidelines to serve as a reference system for naming map units.

Soil Taxonomy provides two kinds of terms: (1) names of taxa to designate the components of map units and (2) adjectives to qualify either the components, their phases or the entire area covered by a map unit.

The names of taxa at any of the six categories of *Soil Taxonomy* may be used as reference terms in the names of map units (Figure 2.6). The categorical level depends mainly on the scale of the maps, but more than one level can be used in one survey and on maps of the same scale.

2.5.1 Names of Taxa

2.5.1.1 Soil Series

The soil series forms the lowest category of *Soil Taxonomy*. Series are the most narrowly defined and most homogeneous taxon, and it most nearly meets the requirements for categorical detail demanded by the objectives of detailed soil resource inventories.

Soil series names are mainly place names adopted from the names of towns, counties, rivers, or other geographic features of the area where the soils were first described or from an area where the series is prominent. Sometimes the name is "coined" if other suitable names are not available.

It is important to point out that the series is a taxonomic unit. When the name of a (taxonomic) series is used to designate a map unit in a legend, the name only serves as a label referring to *Soil Taxonomy*. It informs that soils which occur in the map unit dominantly belong to the named series as defined in the system.

This has various consequences: first, that local names used directly to designate map units, *without any reference* to a taxonomy, are not series names, and actually fall outside the discussion on the use of *Soil Taxonomy* in soil map legends. Second, that the naming of soil series needs to be officially agreed upon by a soil correlation office which creates *established series*, and recognizes tentative series, taxadjuncts, variants, etc. (Figure 2.7).

It may be important to repeat some remarks made earlier: *Soil Taxonomy* is comprehensive at the order, suborder and great group levels in the sense that all soils, even those which have not been recognized or identified at lower levels, find a place in the system. This is not true at the subgroup, family and series levels, for which *Soil Taxonomy* only provides a classification for the soils which have been found to exist. Some unknown soils may or may not have at present an appropriate subgroup, and

Figure 2.7: Soil series names must be established in a centralized manner for maximum usability.

consequently cannot be classified at family and series levels. The Soil Conservation Service policy is to classify these soils tentatively in the closest related subgroup and describe the problem in the remarks section on the official series description. These tentative units form the data base upon which amendments to *Soil Taxonomy* will be based to establish the appropriate subgroups.

It is often thought that all unclassified pedons should automatically justify the establishment of new series, families or subgroups. This is not always true. Unclassified pedons only justify the establishment of new taxa, when they are dissimilar from existing taxa at comparable categorical levels and when they cover areas large enough for the purposes of the classification. Judgement should be exercised in "establishing" new series to avoid unnecessary proliferation of units. Mechanisms to report deviations from strict taxonomic definitions, such as those provided by special units as variants and taxadjuncts are available to fill the hiatus between taxonomic units and map units.

2.5.1.2 Potential New Soil Series

Soils which fall outside the limits of established soil series and have unique *sets* of properties are potential new soil series. When such soils are first recognized, they are described and identified as taxa of the lowest category of *Soil Taxonomy* in which they can be classified. For some soil resource inventories, these taxa can be used as the reference term to identify a map unit. For others, greater refinement of definition is needed. For these, the soils are named as new soil series, but remain *tentative series* until their properties can be described in detail, their extent determined, and any conflicts with previously established series can be resolved. If the soils prove to be unique kinds of significant extent, they are *correlated* and become new *established* series in the national taxonomy.

Some potential soil series occupy only small aggregate areas. These are named as *variants* of the most closely related established series, indicating a principal difference from the established series in the name. "Gale Variant silt loam, 0 to 3 percent slopes" is an example.

Map units are commonly identified as variants if their aggregate known area is less than about 800 hectares. Variants are potential soil series, and if a significant area of a variant is found at some future date, the soil is named and defined as a new soil series. Some soils that contrast strongly with any established series are named and defined as soil series even though the total known extent is less than 800 hectares.

Taxadjuncts are also soils which fall outside the definition of established taxa. They have been discussed in Chapter 1 in the section dealing with similar soils (section 1.3.1.1).

The establishment of soil series is the task of a correlation office. Most soil resource inventory agencies in developing countries have no such office, or have not been able to maintain a soil correlation group for periods long enough to assure continuity from one survey operation to another. For effective performance the agencies responsible for soil resource inventories need a permanent soil correlation staff, and adequate data management and communication facilities.

The rules for using soil series names to designate map units are given in Chapter 4. They are valid for one survey when no correlation with other surveys is available. They can serve several surveys, only if they are correlated via a taxonomic system.

2.5.1.3 Soil Families

The names of soil families are useful for many soil resource inventories. As the taxonomic names of families are long, shorter common names have to be selected. These are the names of prominent or well-known series within families. For example, the family of "fine-loamy, mixed, mesic Ustollic Haplargids" currently includes 28 established and tentative soil series. The Fort Collins series is a well-known and extensive member, and this name is used as the common name of the family as well as the name of a member series. To distinguish between the two, the common name of the family always includes the word "family", i.e.: Fort Collins family.

2.5.1.4 Taxa of Higher Categories

The names of taxa in the four highest categories of *Soil Taxonomy* can be used to designate map units. "Umbric Tropaquults" at the subgroup or "Inceptisols" at the order level, are examples. The names are used as collective terms to imply that the map unit is composed of a number of polypedons of the named taxon, plus inclusions. Thus the plural is used.

2.5.2 Qualifying Terms

2.5.2.1 Cognate Terms from Soil Taxonomy

Soil Taxonomy uses many word-elements in its nomenclature to convey a common meaning in different classes. These "cognate" terms can be used to qualify subdivisions of taxa or phases of the higher categories for general soil maps. An example is *aqu* from *aqua*, meaning water. The adjective form "aquic" is used to identify subgroups of moderately wet soils in great groups of soils that are predominantly not wet. Use of the term can be illustrated for

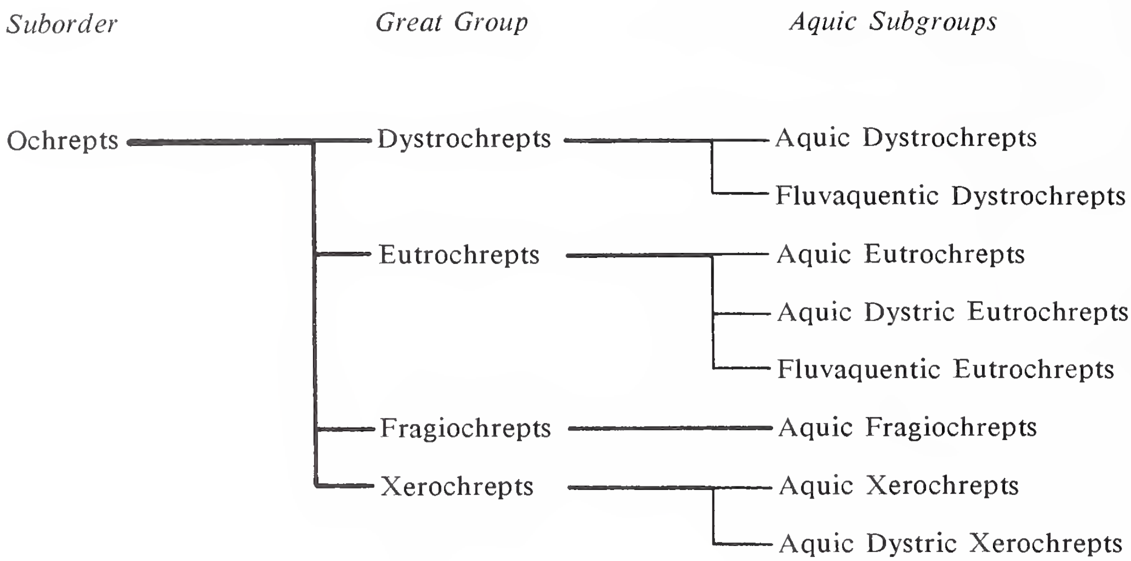

Figure 2.8: Some cognate terms used by Soil Taxonomy.

the suborder, Ochrepts. The Ochrept suborder consists of seven great groups. Four of the seven have aquic subgroups, as seen in Figure 2.8.

To treat all the eight "aquic subgroups" as a unit, the name "Aquic Ochrepts" can be used. The name stands for a *cognate group*[4] of eight subgroups. A cognate group of taxa at a low categorical level is a phase of parent taxa at a higher categorical level. For example, the eight aquic subgroups in the example (Figure 2.8) are a cognate group, and that *group, collectively, can be identified as an "aquic phase" of the Ochrept suborder.* Terms of this kind are usually used to name phases of taxa two categories above the one in which the term is used to name classes.

When cognate terms are used to name map units, the nomenclature follows the conventions for naming phases. If the name of the map unit is identified in terms of a single taxon, the cognate phase term follows the name of the taxon and is separated from it by a comma. For the example above, the name "Ochrepts, aquic" not "Aquic Ochrepts" is used. This convention permits alphabetizing lists of map units according to the names of the taxa, not the names of their phases. Cognate terms may also be used to name associations and undifferentiated groups of soil phases. Although cognate terms may be capitalized in the names of some taxa, they take lower case letters, as common adjectives, when used for names of cognate groups or as phase designations.

Cognate phases are most useful in map units for the large delineations of small-scale general maps. Many of the cognate terms, such as aquic, halic, and lithic, apply to properties of soils that typically occupy small areas associated with unlike soils. Such cognate phases are less useful than others for general soil maps. Other cognate terms, such as "cryic", "frigid", "mesic", and "udic" generally apply to large areas and are useful for naming map units of general soil maps. Examples are (1) "Ochrepts, mesic", (2) "Ochrepts-Aquepts association, mesic" (Figure

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4. The adjective, "cognate", means kindred or allied. It is applied to words of a language to signify that they have a common root. It is used here to signify the relationships among soils that have a common connotative term in their names.

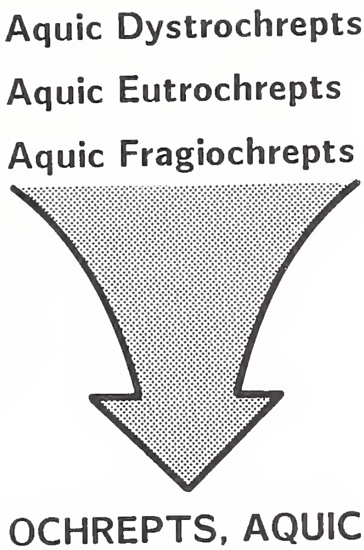

Figure 2.9: Cognate terms can be used to qualify large areas.

2.9) and (3) "Ochrepts or Aquepts, mesic". The examples are names of (1) a cognate phase of a single taxon, (2) an association of cognate phases, and (3) an unassociated group of cognate phases, respectively.

Examples of cognate terms that lend themselves to identifying groups of taxa, either in writing or in phase names of map units are given in Table 2.1.

2.6 Phase and Area Distinctions

The same set of terms can be used to qualify either the *components* of map units separately (taxa or miscellaneous areas), or the entire *area* covered by a map unit.

An example of a component qualification is: "Torriorthents, very stony - Lithic Camborthids association". The "very stony" phase specification only applies to the Torriorthent component.

If the components of a mapping unit are identical in their phase criteria, the phase qualifier is only written once: the example "Oxic Paleustalfs - Typic Eutropepts association, gravelly substratum" identifies identical phases of *two* separate subgroups.

A third example where the individual components are qualified is "Oxisol-Ultisol association, isomesic". In this case all the components are phases having an isomesic temperature regime. The unit could also be designated as "Oxisol-Ultisol association, cool areas", but the first alternative is preferred, if enough information to determine the temperature regime is available.

Not all area designations can be transposed into phases. Examples are gullied areas, rocky areas, where the gullies and the rock outcrops do not represent soil taxa.

2.6.1 Soil Phases

A *soil phase* is a subdivision of a class of the taxonomic soil classification system or of a variant. Phases are also used to subdivide kinds of miscellaneous areas. Phases are differentiated on the basis of criteria chosen to create units useful for predictions about use, management, or behavior of land. Five attributes of *soil phases* must be clearly understood:

1. *Soil phases are functional units of soil.* They are created deliberately to serve the specific purposes of *individual* soil resource inventories, including both applied objectives and understanding of soil geography.

2. *Any attribute not already used as a criterion to distinguish the taxa of the soil name, or any combination of attributes, may be used as differentiating criteria for phases.* Their selection is governed by the purposes they serve. They need not be soil properties, but must be associated with the areas of soil as mapped.

3. *Any limiting value or range of a phase criterion may be used to define phases.* The choice of limits is determined by the purpose and how consistently they can be applied. As objectives differ from one soil resource inventory to another, limits or ranges of the same property may differ among soil resource inventories.

4. *Phase criteria may be applied to any class of any category of the taxonomic system.* Phases of soil series, families, subgroups, or even orders, may be used, depending on the purposes to be served (Figure 2.10).

Table 2.1. Examples of cognate terms for identifying groups of taxa.

Cognate Term	Connotation	Category in Which the Term is Used to Name Taxa
aquic*[1]	intergrading in wetness to soils of aquic moisture regimes	subgroups
arenic	sandy	subgroups
calcic	having a calcic horizon	great groups
cryic	cold	great groups
cumulic*	thickened epipedon	subgroups
fragic	having a fragipan	great groups & subgroups
frigid	cold	families
halic*	salty	great groups
lithic*	shallow to hard rock	subgroups
mesic	temperate	families
pergelic	having permafrost	subgroups
paralithic	shallow to soft rock	subgroups
plinthic*	having plinthite	subgroups
thermic	seasonally warm	families
tropic*	continually warm	suborders
udic*	usually moist	suborders
ustic*	commonly moist, but dry at times	suborders

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1. The terms marked with an asterisk are generally less useful than the others as names of phases of map units of general soil maps either because the soils commonly occupy small areas or because the terms are used too high in the taxonomic system.

5. *Phases are used to subdivide taxonomic classes, but soil phases do not themselves constitute a category of the taxonomic system.* The limits of phase criteria are not fixed from one soil resource inventory to another, as they would be if they were taxa. Phases are adjusted to fit objectives. Their ranges may overlap from one survey to another.

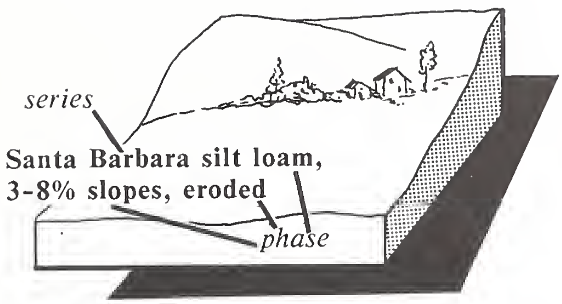
All of the attributes of the taxon to which phase criteria are applied are also attributes of the phases created. All of the differentiating properties that have accumulated from the categories of the taxonomic system down to the class to which phase criteria are applied are also differentiating properties of the phase. Phase criteria merely subdivide a taxonomic set of properties to create additional homogeneity needed for some purpose.

Phases for textures of the surface layer, organic surface layers, mineral cover, coarse fragments, slope, depth, substratum, soil water, salinity, sodicity, physiography, erosion, thickness and climate are given in Appendix A.

2.6.2 Area Distinctions

For some purposes attributes of *areas* need to be shown in names of map units even though these are attributes of land areas rather than attributes of the reference taxa used in naming kinds of soil. Phases are not appropriate for such uses, as they are subdivisions of soil taxa, variants, or kinds of miscellaneous areas.

Terms that are not attributes of reference taxa are used to *qualify* map unit names in terms of limiting features of *entire areas*. These qualifying terms are perhaps most useful for characterizing features of the areas of soil associations of small-scale maps, but they are also used for some units of detailed maps.



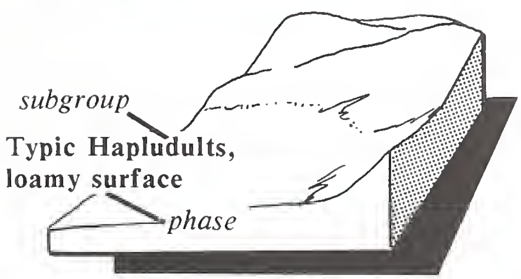


Figure 2.10: Phase criteria can be used at any level of Soil Taxonomy.

Groups of soils which share common properties and which consistently occupy mappable areas in the field, but which cannot be satisfactorily designated by names of taxa at any level, may be qualified by diagnostic terms borrowed from *Soil Taxonomy* or other systems.

Rock outcrop in areas of soil is an example of an attribute of areas. A map unit that is a geographic mixture of soil and rock outcrop is named and defined as a complex if the rock outcrop is more than 10 percent of the area: a complex of a soil and a kind of miscellaneous area. Even if the rock outcrop is less than 10 percent of the area, it may be extremely important for use of the area. The unit cannot be identified as a phase of the soil, for the rock is "not-soil"; it is not a property of the soil identified. A *qualifying* term is used to show that the unit includes rock outcrops. The names "Typic Ustropepts, *rocky areas*" and "Typic Ustropepts, *very rocky areas*" qualify two map units in terms of attributes of the areas. To distinguish the qualified unit from phases, the word *area* is used. Classes used for rock outcrops are defined in Appendix A (section 5.1).

Gullied lands can be recognized as "gullied areas". They are used for areas having gullies so deep that intensive measures, including reshaping, are required to reclaim the soil.

Climate may also be used to qualify areas. Climatic qualified units are based on air temperature and precipitation. In some places, especially in mountainous or hilly areas, precipitation or air temperature may be significantly different within short distances, and the difference may not be reflected in internal properties of the soil. The range of atmospheric climate for a soil series may be relatively large, though the range is small enough that related *soil temperature* and *soil moisture regimes* do not exceed limits used as criteria for taxonomic soil classification. For this reason the soil series sometimes cannot be subdivided into climatic phases. An example may clarify this point. Air drainage can differ enough on the same soil series to produce a significant difference in the date of the last killing frost in the spring or the first killing frost in the fall at one location compared to another. On some alluvial fans that extend from the foot of a mountain into a basin in arid regions, precipitation varies significantly without producing marks in the soil that justify separation of soil series. Where differences of these kinds are significant for the purposes of the survey and can be identified and mapped consistently in the field, climatic qualified units are used. Only two climatic conditions have been recognized for a single soil series: (1) the common climate for the series, for which the climatic designation is omitted, and (2) a departure from the common climate, for which a climatic qualification is designated. The departure may be in either of two directions from the norm, and qualifications for two departures of temperature and of precipitation from their norms are used, as follows:

Warm areas	High precipitation areas
Cool areas	Low precipitation areas

Each of the terms is connotative only in reference to the common atmospheric climate for the soil series and must be described specifically for each map unit to which it is applied.

Climatic qualifications are defined relative to a norm for the series *within the limits of its range in a single soil resource inventory area.* In many places, especially on plains, precipitation or temperature change gradually over distance. A soil series in a

single soil resource inventory area commonly includes only part of the range of climate normal for the series. Climatic qualified units are *not* used to signify that only part of that range is found in a soil resource inventory area. Climatic qualified units are local distinctions. They are used where temperature or precipitation are markedly different within parts of a single soil resource inventory area.

A great variety of other area distinctions can be made. In addition to those already described, others may be needed to provide suitable map units, for example: *frequently flooded, occasionally flooded, burned*. "Burned" for example, might be used for organic soils that have lost enough of their organic material by fire that their potential for use or their management requirements have been altered.

2.7 Kinds of Miscellaneous Areas

Kinds of miscellaneous areas are detailed in Appendix B.

Miscellaneous areas have essentially no soil and support little or no vegetation without major reclamation, because of active erosion, washing by water, unfavorable soil conditions, or man's activities. Some miscellaneous areas can be made productive but only after major reclamation efforts. Map units are designed to accommodate miscellaneous areas, and most map units named for miscellaneous areas have inclusions of soil. If the amount of soil exceeds the standards for inclusions defined earlier, the map unit is named as a complex or association of a miscellaneous area and soil.

CHAPTER 3

Kinds of Soil Surveys and Their Map Units[1]

3.1 Characteristics and Uses of Soil surveys

A soil survey is a field investigation of the soils of a specific area supported by information from other sources. The kinds of soils in the survey area are identified and their extent shown on a map, and an accompanying report describes, defines, classifies, and interprets the soils. Interpretations predict the behavior of the soils under different uses and the soils' response to management. Predictions are made for areas of soil at specific locations. Soils information collected in a soil survey is useful in developing land-use plans and alternatives involving soil management systems and in evaluating and predicting the effects of land use.

A soil map delineates areas occupied by different kinds of soils, each of which has a unique set of interrelated properties characteristic of the material from which it formed, its environment, and its history. The use of *Soil Taxonomy* to name map units, as discussed in this paper, is useful in transferring knowledge from one area to another with the same or similar soils.

Soil surveys also provide essential data and information for the compilation of general soil maps. Many soil surveys are done for purposes that require relatively intense field investigation and map scales of about 1:12,000 to 1:24,000. However, a smaller scale soil map with more broadly defined units may be better for some uses, such as developing land-use plans for large-scale soil maps by generalizing the map detail. The resulting map units are more useful for the intended use. The scale of the general soil map is usually selected to be the same as the land-use planning map.

Small-scale soil maps provide a basis for comparison of broadly defined capabilities and limitations that relate to the soil on regional, national, and even worldwide scales. International cooperation among soil scientists has accomplished much in relating the different soil classification systems of various countries to one another. This permits extending the findings of research on soils of one country to similar kinds of soils elsewhere. Since 1960, many people in many parts of the world have been working with *Soil Taxonomy*. Many have contributed ideas and data that form the basis of this system. As a result, the uses of soil survey data have been extended far beyond the boundaries of the countries where the data were obtained.

3.2 Map Scales, Map Units and Kinds of Soil surveys

The *map scale* must be large enough that areas of the minimum size can be delineated legibly. The choice of map scale also depends on the user's perspective. Users who need precise information about small areas focus their attention on a small part of the map and on a relatively few delineations. They are not distracted by boundaries and symbols on other parts of the map. Consequently, the map scale can usually be the smallest that will permit legible delineation of the smallest areas.

Map users who want a broad perspective of large areas, however, are usually concerned with comparisons among delineations of all, or a large part, of the map. Many closely spaced

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1. From Soil Management Support Services, Soil Conservation Service. November 1984, Soil Taxonomy News #9 and April 1985, Soil Taxonomy News #10.

boundaries and symbols are confusing. Consequently, delineations on maps for such uses are generally larger and fewer in number. Although such maps are usually at smaller scales, the scale used is commonly larger than the minimum that would permit legible delineation of the smallest areas.

Table 3.1 shows the relationships between map scales and the smallest delineations that can be made legibly at those scales. The difference between the smallest delineation that *could* be made and the smallest that *is* commonly made increases as map scale decreases.

When the elements of the soil survey are skillfully coordinated with the purposes for making the survey, the needs of the users can be met. The order of a survey is a consequence of field procedures, the minimum size of delineation, and the kinds of map units that are used. Table 3.2 is a key for identifying kinds of soil surveys.

Table 3.1. Guide to Map Scales and Minimum Delineation Size

Map scale	Inches per mile	Minimum-size delineation[1] acres	hectares
1:500	126.7	0.0025	0.001
1:2,000	31.7	0.040	0.016
1:5,000	12.7	0.25	0.10
1:7,920	8.00	0.62	0.25
1:10,000	6.34	1.00	0.41
1:12,000	5.28	1.43	0.57
1:15,840	4.00	2.5	1.0
1:20,000	3.17	4.0	1.6
1:24,000	2.64	5.7	2.3
1:31,680	2.00	10.0	4.1
1:62,500	1.01	39	15.8
1:63,360	1.00	40	16.2
1:100,000	0.63	100	40.5
1:125,000	0.51	156	63
1:250,000	0.25	623	252
1:300,000	0.21	897	363
1:500,000	0.127	2,500	1,000
1:750,000	0.084	5,600	2,270
1:1,000,000	0.063	10,000	4,000
1:5,000,000	0.013	249,000	101,000
1:7,500,000	0.0084	560,000	227,000
1:15,000,000	0.0042	2,240,000	907,000
1:30,000,000	0.0021	9,000,000	3,650,000
1:88,000,000	0.0007	77,000,000	31,200,000

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1. The "minimum-size delineation" is taken as a 1/4-inch square area (1/16 sq. in.). Cartographically, this is about the smallest area in which a symbol can be printed readily. Smaller areas can be delineated, and the symbol lined in from outside, but such very small delineations drastically reduce map legibility.

Every soil survey is produced with a purpose or set of purposes in mind. Different phases or levels of abstraction in defining and naming map units are related to different intensities of field study, different degrees of detail in mapping, and different map unit designs to produce a wide range of soil surveys (Table 3.2). Adjustments of the elements, including naming map units form the basis for differentiating *five orders of soil surveys*.

Table 3.2. Key for Identifying Kinds of Soil surveys

Level of data needed	Field procedures	Land area represented by the minimum-size delineation (hectares[1])	Typical components of map units	Kinds of map units[2]	Appropriate scales for field mapping and publication
1st order - Very intensive (i.e., experimental plots, individual building sites)	The soils in each delineation are identified by transecting or traversing. Soil boundaries are observed throughout their length. Remotely sensed data is used as aid in boundary delineation.	1 or less	Phases of soil series; miscellaneous areas	Mostly consociations; some complexes	1:15,840 or larger
2nd order - Intensive (i.e., general agriculture, urban planning)	The soils in each delineation are identified by transecting or traversing. Soil boundaries are plotted by observation and interpretation of remotely sensed data. Boundaries are verified at closely spaced intervals.	0.6 to 4	Phases of soil series; miscellaneous areas; few named at a level above the series	Consociations and complexes; some undifferentiated and associated	1:12,000 to 1:31,680
3rd order - Extensive (i.e., rangeland, forest land, community planning)	The soils are identified by transecting representative areas with some additional observations. Boundaries are plotted mostly by interpretation of remotely sensed data and verified with some observations.	1.6 to 256	Phases of soil series and levels above the series; miscellaneous areas	Mostly associations or complexes; some consociations and undifferentiated groups	1:20,000 to 1:250,000
4th order - Extensive (i.e., regional planning)	The soils are identified by transecting representative areas to determine soil patterns and composition of map units. Boundaries are plotted by interpretation of remotely sensed data.	40 to 4,000	Phases of levels above the series; miscellaneous areas; phases	Mostly associations; some consociations, complexes and undifferentiated groups	1:100,000 to 1:1,000,000
5th order - Very extensive (i.e., selections of areas for more intensive study)	The soil patterns and composition of map units are determined by mapping representative areas and applying the information to like areas by interpretation of remotely sensed data. Soils are verified by occasional onsite investigation or by traversing.	1,000 to 4,000	Phases of levels above the series; miscellaneous areas	Associations; some consociations and undifferentiated groups	1:5000,000 to 1:1,000,000 or smaller

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1. This is about the smallest delineation allowable for readable soil maps. In practice, the minimum-size delineations are generally larger than the minimum-size shown.

2. Where applicable, all kinds of map units (consociations, complexes, associations, undifferentiated groups) can be used in any order of soil survey.

CHAPTER 4

Rules of Nomenclature

4.1 Conventions for Naming Components of Map Units

The following conventions govern the use of names of taxa as reference terms for map units:

1. *The taxonomic reference term to designate the components of a map unit name may be either:*

a. *The name of a single taxon in which a single class identifies the soil, or*

b. *The names of two or more taxa, which together characterize the soils.*

This can be illustrated by the following example. The Kaneohe and Lolekaa series of Hawaii are both members of the clayey, oxidic, isothermic Humoxic Tropohumults family - the Kaneohe family. It is a family of 10 established and tentative soil series. For some purposes, similar phases of the Kaneohe and Lolekaa series may be mapped under a single symbol--as one map unit. The Kaneohe family is the taxon of the lowest category that includes the diagnostic properties of both series. The term "Kaneohe family" can be used as the reference term in the map unit name under alternative *a* above. Or by alternative *b*, the two series names can be used together to designate an undifferentiated group, i.e., "Kaneohe and Lolekaa soils" (Figure 4.1). Either name is acceptable. "Kaneohe and Lolekaa soils" describes the unit more precisely. It tells the user that only soils having properties of these two series are the dominant constituents. "Kaneohe family" implies that the user may expect to find any part, or all, of the range of the family, including the eight soil series that are not included. The name of the undifferentiated group of alternative *b* is

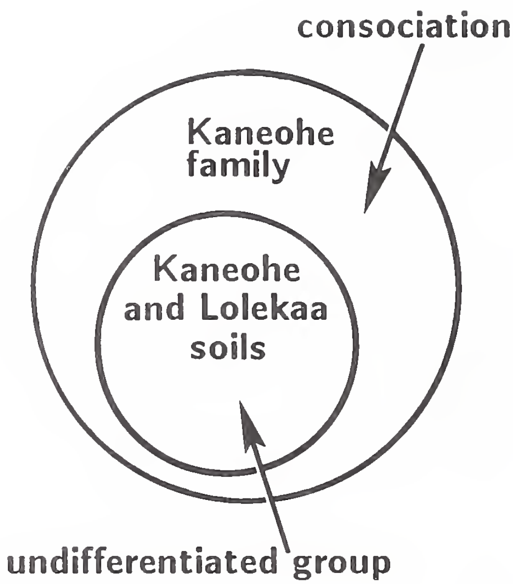

Figure 4.1: Two different names for the same map unit do not necessarily mean the same thing.

generally preferred for that reason. For some map units, four or more soil series may be included. A list of so many series names is so long and cumbersome that a single name of a higher category is preferred. Some map units do encompass the entire range of a soil family; the family name accurately characterizes such map units.

2. *A taxonomic name used as a reference term for a map unit implies no specific range of properties within the limits of the taxon.*

A map user cannot tell from the name whether all or only part of the range of the taxon is included unless the name is modified by a phase designation. In the example under item *1* above, the Kaneohe and Lolekaa series together do not encompass the range of the

Kaneohe family. Use of "Kaneohe family" as the reference term implies that the soils are within the range of that family but does not imply that any or all areas delineated under that name necessarily encompass the entire range. The range of properties in each map unit must be described and *the person using the soil map must always read the descriptions of the map units.*

3. *The names of soil series and soil families (if "local" names) are used as reference terms only as adjectives (adherent nouns) modifying another noun.*

Soil series and common family names are also names of other things. They can cause confusion if used alone. Soil series names commonly modify a phase of surface soil texture, as "Enfield silt loam", by special convention, or they may modify the word "soils", as "Enfield soils". *Note that the term "soils" is plural.* Common names of families are always used as a modifier of the word "family", as "Avonburg family".

4. *The names of taxa used as reference terms are used as collective terms.*

The intent is to imply that a map unit is composed of some number of polypedons of the named taxon (plus inclusions). Thus, the plural is used as "Aeric Fragiaquepts", "Aquepts", and "Inceptisols", not "Aeric Fragiaquept", "Aquept", and "Inceptisol". The word "soils" used with series names is plural; the word family is a collective noun implying several kinds of soils and is singular.

4.2 Conventions for Naming the Primary Kinds of Map Units

4.2.1 Consociations

4.2.1.1 Consociations of Soil Phases

Names of phases can be long, and various devices are used to keep them as short as possible. The term "phase" is usually omitted, relying on the construction of the name to show that the unit is a phase.

It is useful to identify the soil properties that distinguish one phase from another in the same legend. Only those properties which differentiate some phases from other soils are used in the map legend. For example, the term "gravelly substratum" would not be used if the substratum of a given series is normally gravelly or if a phase having a non-gravelly substratum is not recognized in the same legend.

The descriptive terms used are given under appropriate headings in the subsections that follow. The order in which they are used when two or more terms are needed is subject to some judgment.

1. The term for the reference taxon, variant, or kind of miscellaneous area appears first in the phase name, as in all of the examples that follow.

2. The name of any phase of surface-layer texture of a soil series or any phase designating the state of decomposition of an organic surface layer of a soil series follows the series name without a comma, as in "Alpha loam", "Beta peat".

3. If a phase of surface layer texture of a soil series is also a stony, bouldery, gravelly, etc. phase, the appropriate term is inserted between the name of the series and the textural term, as in "Alpha gravelly loam".

4. All other phase designations are separated from the reference term by a comma. Terms for texture of the surface layer and for coarse fragments, stones, and boulders are also separated from the reference term by a comma for the following special conditions:

- *if the texture of a surface layer phase is not designated, terms for stony, bouldery, or coarse fragment phases are separated from the reference term by a comma, as in "Alpha soils, stony", "Alpha soils, bouldery".*

- *terms for the texture of a surface layer are separated from the reference term by a comma if the reference taxon is a member of a category above soil series, as in "Alpha family, coarse textured surface".*

5. Two or more phase designations other than those of item 3 are separated from each other by commas, as in "Alpha loam, 3 to 8 percent slopes, eroded".

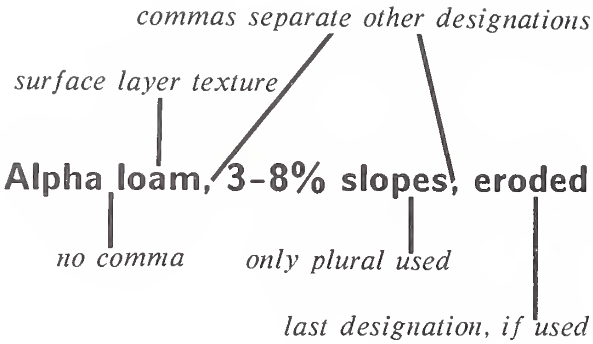

Figure 4.2: Example of a map unit name that includes phase names.

6. The phase designation for an eroded soil or deposition is usually the last term in the name, as in the example above.

7. A designation for slope phase usually follows all other phase terms except that of an eroded phase, as in "Alpha loam, gravelly substratum, 3 to 8 percent slopes, eroded".

8. With the exception of the word "slopes" and terms for textural groups, nouns in phase designations are singular in number. Example 7 uses "substratum", not "substrata", but it uses the plural "slopes". The convention is used to avoid names in both singular and plural form for the same kind of phase (Figure 4.2).

The names of soil-texture classes or soil texture groups may be used to name phases of surface-layer texture. Basic soil-texture class names, such as "sand", "fine sandy loam", and "silt loam", follow the name of a soil series without an intervening comma in phase names. The terms for textural groups, such as "medium textured", and "loamy" are set apart from the term for any reference taxon by a comma, as in "Alpha family, loamy surface". The term "surface" must appear in such names to avoid confusion with phases based on texture of other parts of the soil, but to keep the name as short as possible, the term "surface" is used instead of "surface layer".

4.2.1.2 Consociations of Soil Series

Soil series names may be used without qualification by phase criteria to name map units. When they are used in this way, the word "soils" is added. "Huntington soils", for example, may be used as the name of a map unit. It implies that a map user can expect to find any combination of properties within the range of the Huntington series as defined for the survey area in the delineation identified by its symbol. That range includes properties that are phase criteria, such as surface layer texture, contrasting material below the series control section, slope, and the like.

4.2.1.3 Consociations of Soil Families

As mentioned in Chapter 2, soil family names can be used to designate consociations of a soil family. They are useful in many semi-detailed soil resource inventories. As the taxonomic names of families are long, shorter common names may be selected. These are the names of prominent or well-known series within families. For example, the "fine-loamy, mixed, mesic Ustollic Haplargids family" currently includes 28 established and tentative soil series in the United States. The Fort Collins series is a well-known and extensive member, and this name is used as the common name of the family as well as the name of a member series. To distinguish between the two, the common name of the family always includes the word "family", i.e. Fort Collins family.

4.2.1.4 Consociations of Higher Taxa

"Oxic Paleudults", "Haplorthox", "Ustalfs", and "Ultisols" are examples of names of consociations of higher taxa.

4.2.2 Complexes

Names of taxa, variants, and kinds of miscellaneous areas can be used as the reference terms in the names of soil

complexes. The names of miscellaneous areas and variants are used in the same way as the names of taxa. The discussion that follows refers to the "dominant soil" as the kind of greatest average extent in delineations of a complex. It uses "subordinate soils" for the second and third most extensive kinds of soil identified as constituents of a complex.

On detailed maps soil series names are the most frequently used. Five primary considerations govern the conventions for naming soil complexes:

1. *The form of the name must distinguish the name of a complex from names of other kinds of map units, such as a soil association.*

2. *The form of the name must distinguish between terms that identify attributes of individual components and those that identify attributes of entire delineations of complexes. The first applies to complexes of soil phases; the second, to "qualified" complexes, called area distinctions (section 2.6.2).*

3. *The conventions must allow unique names to be devised for all complexes in a single legend.*

4. *The conventions must allow the name of a complex to identify attributes of individual components that are outstandingly important for uses of the survey.*

5. *The names must be as short and simple as possible.*

Items 1 through 3 impose essential conventions for names. Items 4 and 5 permit discretion in the use of some conventions.

Names of either two or three taxa may be used as the reference term in the name of a soil complex. They are joined by a hyphen, as in *Sharkey-Alligator complex.* Use of the hyphen distinguishes the names of complexes from those of undifferentiated groups and unassociated groups. The reference terms for the first of these are joined by "and", and of the second by "or".

Names of two or three series are used if all merit identification in the name on the basis of their importance for interpretations of the map unit, or if they are necessary to distinguish one complex from others in the same legend. Names of two series are used if both are extensive or if the one of smaller extent is highly contrasting with the dominant soil. A third name of a series is not used unless the soil is a very important or characteristic component, or the name is needed to distinguish the complex from other map units. The series names are listed in order of their decreasing extent in delineations and are separated by hyphens, as in *Skaggs-Duncan-Hughsville complex.*

Either of two conventions is used to distinguish complexes from soil associations. The word "complex" may be added to the reference term, as in *Sharkey-Alligator complex.* This is preferred. If it is important to identify texture of surface layers in the name, or if it is necessary to distinguish between two complexes of the same soil series in the same legend, a term for phase of surface layer texture may be used. This is normally done only if the texture of surface layers of the series identified are the same. The term for texture may then be used in the *plural* form to show that it applies to two or more named series, as in *Sharkey-Alligator clays.* This implies that the unit is a complex of Sharkey clay and Alligator clay. If a term for rock fragments is needed, it may be used with a term for the texture of the surface layer, as in *Lima-Kendaia gravelly loams.*

All terms for phases other than those for surface layer texture, and terms for rock fragments used with texture, follow the reference terms to which they apply and are separated from it by a comma, as in *Denton-San Saba clays, 2 to 5 percent slopes* and *San Saba-Springerville complex, 0 to 5 percent slopes.* These names imply that the map units are complexes of two phases of slope of similar gradient but different soil series. Phases for rock fragments used without a term for texture of surface layer are named similarly, as in *Coveytown, very stony-Mojra complex.* Otherwise a user may assume that the phase term applies to both series.

Qualified complexes are used to identify important attributes of entire delineations, as distinct from attributes of the individual components of the complex. The word *"areas"* (plural) is used to signify that the qualifying term applies to entire delineations. The name *Lima-Kendaia complex, gently rolling areas* for example, signifies that entire delineations are gently rolling. The description of this complex would explain that the Lima soils occupy 5 to 10 percent convex slopes in areas intricately intermingled with

Kendaia soils having 2 to 5 percent concave slopes. Qualified nomenclature of complexes is used to identify an important attribute of entire delineations which is not appropriately a criterion of a phase of each of the named taxa. The attribute may be one that is expressed unequally among component taxa, or it may be one that is not a phase criterion.

The following examples illustrate the conventions described:

Sharkey-Alligator complex: A complex of phases of two soil series, phases unspecified.

Sharkey-Alligator clays: A complex of like phases of surface layer texture of two soil series.

Lima-Kendaia complex, gravelly: A complex of like phases of coarse fragments of two soil series.

Lima-Kendaia gravelly loams: A complex of like phases of surface layer texture and coarse fragments of two soil series.

Gem-Springerville complex, 0 to 5 percent slopes: A complex of like phases of slope of two soil series.

Denton-San Saba clays, 2 to 5 percent slopes: A complex of like phases for surface layer texture and slope of two soil series.

Coveytown, very stony-Moira complex: A complex of unlike phases of two soil series.

Vergennes-Denton complex, rocky areas: A complex of two soil series qualified for an attribute that is not a phase criterion.

Travessila-Rock outcrop complex: A complex of a soil series and a miscellaneous area.

Skaggs-Duncan-Hughsville complex: A complex of three soil series.

4.2.3 Soil Associations

Soil associations are geographic mixtures of taxonomic units which occur in definable patterns in the landscape. The grouping of the taxonomic components can occur at different levels; when as a first step the association combines single taxonomic units, the association is a "primary kind" association.

The shortest and simplest names are used that will convey the essential concepts of map units and differentiate them from others. The names of soil associations consist of either two or three parts:

1. *the name or names of important soil taxa and/or kinds of miscellaneous areas used as reference terms;*

2. *the word "association" to distinguish this kind of map unit from all others;*

3. *phase or qualifying designations as needed.*

Parts (1) and (2) are essential; part (3) is used when it is important to show that the range of an attribute is limited. *The form of the name and the general conventions are similar to those for soil complexes; the word "association" distinguishes the two.*

The reference terms are given first, and if two or more are used, they are separated by hyphens. *Cohoe-Kenai association* and *Ruston-Cuthbert-Shubuta association* are examples. The names of taxa within any category may be used, as in *Aquepts-Ochrepts association* or *Haplaquepts-Dystrochrepts association*. The names of kinds of miscellaneous areas are treated as if they were names of soil taxa, as in *Hollis-Rock outcrop association.*

The word "association" is used in the names of *all* soil associations. It signifies that at least two consistently associated dissimilar soils are significant for understanding delineated areas and their potential uses. It also distinguishes the broad pattern of constituents in associations from the intricate pattern in complexes.

The use of a third reference term in a soil association name is a matter of judgement of the significance of the kinds of soils in the map unit. As a general rule, a third name is used *only* if it is necessary to differentiate the map unit from another that bears the same first and second names or if the third kind of soil is outstandingly significant for appraisal of the potential for use of delineated areas. Second and third reference terms are used whenever they focus attention on an attribute of the association that merits emphasis; the terms should not be used in the name as a substitute for definition and description.

Phase criteria may be used as modifiers of names of components of soil associations to show that the ranges of the taxa are limited in some respect. As phases are subdivisions of soil taxa, phase terms in names of soil associations apply to the individual components, not to the association as a whole. By this convention, *associations of soil phases are named - not phases of soil associations.* If the phase criterion applies to all named components, it is added at the end of the association name and separated by a comma, as in *Cohoe-Kenai association, steep.* This name signifies that both the Cohoe and Kenai soils of this association are steep. Other kinds of soil included in the association but not identified may not be steep. If one of the named kinds of soil is steep and the other is not, the phase terms are applied to the individual taxa, as in *Cohoe, steep-Kenai association.* Because such names are awkward and may be confusing, they are avoided; and terms that characterize the entire area are used instead.

The examples of names of soil associations that follow illustrate the various conventions that have been described.

1. Associations of soil series

   - *Cohoe-Kenai association* (an association of two soil series.)

   - *Cohoe-Kenai association, steep* (an association of like phases of two soil series.)

   - *Cohoe, steep - Kenai association* (an association of a phase of one soil series and another entire soil series.)

   - *Ruston-Cuthbert-Shubuta association* (an association of three soil series.)

   - *Hollis-Rock outcrop association* (an association of a soil series and a kind of miscellaneous area.)

2. Associations of taxa of higher categories

   - *Crete-Butler families association* (an association of soil families using common family names.)

   - *Typic Fragiochrepts-Aeric Fragiaquepts association* (an association of subgroups.)

   - *Fragiochrepts-Fragiaquepts association* (an association of great groups.)

   - *Ochrepts-Aquepts association* (an association of suborders.)

   - *Fragiochrepts-Fragiaquepts association, fine-loamy, mixed, mesic* (an association of phases of great groups using family criteria as phase designations.)

   - *Ochrepts-Aquepts association, very stony* (an association of like phases of suborders.)

   - *Ochrepts-Aquepts association, thermic* (an association of like phases of suborders using a cognate term as the phase designation.)

4.2.3.1 Qualified Soil Associations

Prominent attributes of *entire* delineations of general soil maps can sometimes be usefully shown in the name. For example, a soil association that consists of rolling and hilly Spodosols as one component and Histosols on associated low-lying nearly level areas as another is a useful map unit for some small-scale maps of glacial drift plains. Perspective of the relationships between the major elements may be provided by characterizing entire delineations as "rolling and hilly glacial drift plains". Such a term qualifies the association *as a unit.* The qualifying term is not a phase designation, for it describes entire delineations, not areas of the individual components. The qualifying term may be added as a *prepositional phrase* modifying the word "association". In the example given, the name would be *Spodosol-Histosol association on rolling and hilly glacial drift plains.* Or it may be added as a modifying term with the word "areas", as in *Spodosol-Histosol association, rolling and hilly areas.* Either form shows that the qualifying term describes entire delineations and is not a phase designation that describes an attribute common to the individual components.

Qualified associations are most useful for schematic and exploratory soil maps at small scales. Commonly, delineations on such maps are related to geomorphic or other kinds of major land areas. Qualifying terms

commonly help the map user to visualize the associated soil landscapes.

4.2.4 Undifferentiated Groups

The names of undifferentiated groups always contain three elements:

(1) Two or three reference terms, commonly names of soil series, used as adjectives to identify the components of the group;

(2) A noun or nouns, such as "soils", for the terms to modify;

(3) The word "and" to signify the combination of components. The word "and" distinguishes the names of undifferentiated groups from names of soil complexes, soil associations, and unassociated groups.

The conventions for naming undifferentiated groups are most easily illustrated for comparable phases of two or more soils. The name of the most extensive soil is listed as the first element of a reference term and is connected to the name of the less extensive one by the word "and", as in "Mardin and Bath".

If three or more soils are included, the names of the three most extensive soils are used in the reference term. They are listed in order of decreasing extent and are separated by commas and the word "and" between the last two terms, as in "Mardin, Langford, and Marilla". A similar phase of a fourth series may be included, but is not identified in the name. This sequence of series names is used as a compound adjective (adherent noun) modifying either the word "soils" or the name of a phase for surface layer texture common to all of the series to complete the reference term. The following are examples of the alternatives:

Mardin and Bath soils, or

Mardin and Bath silt loams.

The nouns "soils" and "silt loams" are plural signifying that they apply to all of the series listed. Long names are cumbersome to use, and the term "soils" is preferred unless special significance is attached to the name of the phase for surface-layer texture. If the components differ in texture of the surface-layers and that property is important enough to designate in the name, the textural term is used with the name of the series to which it applies, as in *Volusia silt loam and Allis silty clay.* Such long names should be avoided.

Names for phases other than surface-layer texture and any associated terms for coarse fragments, stones, or boulders follow the reference term and are separated from it by a comma.

The following are examples of complete names of undifferentiated groups:

- *Mardin and Bath soils, very steep*
- *Mardin and Bath soils, 20 to 35 percent slopes*
- *Mardin and Bath soils, very stony, steep*

An alternative to the names illustrated is to use taxa of higher categories as the reference terms. Phases of taxa of categories above the soil series can then be substituted for some undifferentiated groups. This is possible for the examples given above. Mardin, Bath, and Wellesboro soils are all members of the fine-loamy, mixed, mesic family of the Typic Fragiochrept subgroup, the Bath family. The map units can be named as phases of a family, as in *Bath family, steep* or *Bath family, very stony, steep.* And if members of two families are included in a map unit, an undifferentiated group of phases of families can be used, as in *Bath and Langford families, very stony, steep.*

Many heterogenous map units are most appropriately identified as undifferentiated groups. Special conventions are provided for some of these. In some places, the delineations feasible for some soil series contain large amounts of inclusions of soil unclassified at the series level. If these exceed the limits for inclusions, the unit may be identified by a name such as *Alpha soils and variants.* In areas of very complex soil patterns, the feasible delineations may consist of an established soil series and a large aggregate area of many related kinds of soil, none of which occupies a part large enough to merit recognition in the name. If these exceed the limits for inclusions the unit may be identified by a name such as *Alpha soils and related soils.* These kinds of names are not used by the Soil Conservation Service but they are appropriate for some map units.

The foregoing deals only with map units of taxonomic classes, established or potential.

Areas having no soil may also be mapped as parts of undifferentiated groups. Two or more kinds of such areas may be combined in an undifferentiated group. *Rock outcrop* and *Rubble land* is an example. A kind of area without soil and a taxonomic class may be treated as an undifferentiated group. *Alpha soils, rubbly, and Rubble land* is an example. The conventions for naming undifferentiated groups of kinds of miscellaneous areas are similar to those used for soils. Devices may be employed to make names short. For example, "mine pits", "mine dumps", and "mine wash" are kinds of miscellaneous areas that may be mapped as one undifferentiated group. The name can be *"Mine pits, wash, and dumps"*, avoiding repetition of the word "mine".

4.2.5 Unassociated Groups

The connecting word *or* is used in the name of unassociated groups. "Ultic Haplorthox or Typic Paleudalfs" is an example.

Qualifying descriptive terms can be applied to the names of unassociated groups to provide useful perspectives of such areas. The name *"Paleudults or Tropaquults on nearly level alluvial plains"* identifies a map unit of this kind. The form of the name distinguishes qualified unassociated groups of dissimilar soils from undifferentiated groups of similar soils, which are rarely used on maps of small scale. At very small scales, however, when the objective is to provide broad perspectives of patterns of soils of large areas, map units identified at the suborder or order level may be used effectively. Even for such maps, the map units are usually more appropriately named as associations or unassociated groups of taxa at the great group, suborder, or order levels.

4.3 Conventions for Naming Secondary Kinds of Map Units

4.3.1 Undifferentiated Soil Associations

Just as potential map units named as single taxa may be grouped and treated as one, two or more soil associations may be grouped and treated as a single map unit. This is done when the map scale does not allow their delineation and publication as separate units.

The names of the soil associations are joined by the word "and" and the term "associations" is used in plural form to signify that two distinctive associations of soils are included in one map unit. If three or more soil associations are grouped, the names of the associations are listed in series separated by commas with the word "and" joining the last two terms. The name *"Gloucester-Essex-Rock outcrop and Hermon-Becket-Rock outcrop associations"* identifies a single map unit consisting of two discrete associations. For purposes of a map published at a scale of 1:250,000, their differences do not justify separate treatment. Undifferentiated associations such as this are useful devices for some purposes, but they are used only when two or more distinct associations are combined for practical reasons. The constituent associations are defined as discrete kinds of delineations. Each is defined in terms of its kinds, proportions, and patterns of associated components.

APPENDIX A

Phase Criteria[1]

A.1 Phases for Texture of the Surface Layer

Only a few classes in *Soil Taxonomy* are differentiated specifically on the basis of texture of that part of the soil that is normally stirred in tillage, which is commonly called the *surface layer*. As the surface layer has special significance for growth of plant roots, supplying plant nutrients, water relationships, tillage, deactivation of pesticides, and other factors significant for man's use of soils, its texture is commonly indicated in the names of map units of detailed soil resource inventories.

These phases identify the dominant texture (Figure A.1) of a surface mineral layer approximately equal to that commonly mixed in tillage. The thickness of the layer stirred in tillage varies from region to region, among kinds of soil within regions, and among uses of the same kinds of soils. The texture is identified for a surface mineral layer *mixed* to a depth between 12 and 25 cm (5 and 10"). If the layer has not been mixed, the texture that would be produced by mixing is estimated if the named soil is commonly cultivated or it has potential for growing cultivated crops. If, after mixing, the layer qualifies as organic soil material, phases of organic surface layers, not phases of texture of surface layers, are used.

A.2 Phases for Organic Surface Layers

The terms *peat*, *muck*, and *mucky peat* are common words used to signify the state of decomposition of material that qualifies as organic soil materials. These terms are used to name phases of organic surface layers. *Peat* is used to signify organic soil material in which identifiable parts of the contributing plants are dominant in determining the properties of the material; it is equivalent to the fibric materials of *Soil Taxonomy*. A material is called *peat* if virtually all of the organic remains are sufficiently fresh and intact to permit identification of plant forms. *Muck* signifies organic material having properties dominated by humified organic matter; it is equivalent to the sapric materials of *Soil Taxonomy*. Although some plant parts may be identified, most of the material is finely divided, commonly dark-colored humus. *Mucky peat* is used for materials intermediate in decomposition between peat and muck; it is equivalent to hemic materials of *Soil Taxonomy*.

Conventions for naming phases of organic surface layers are similar to those for phases of textures of surface layers. The phases are used most commonly with soil series of Histosols. "Rifle peat" and "Carlisle muck" are examples. Some mineral soils have organic surface horizons thick enough that the layer normally stirred in tillage is organic after mixing and allowance for decomposition and settling. These may also be identified as "peat", "muck", or "mucky peat" phases.

The term *mucky* is introduced into the designation of surface layer textural phases to signify that the surface layer, though it is mineral soil material, has such a high content of organic matter that its physical properties approach those of muck. *Livingston mucky silt loam* is an example. Such phases are used commonly for wet mineral soils that have surface horizons high in organic matter content.

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1. Source: U.S. Department of Agriculture, SCS, Soil Survey Staff. 1984. Soil survey manual: 430-V, issue 6.

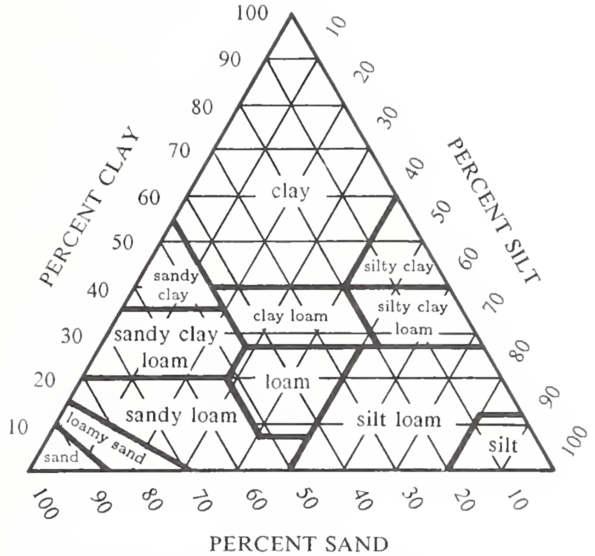

Figure A.1: Textural triangle diagram.

A.3 Depositional Phases

Some soils have received deposits of material thick enough to influence interpretations of the soil but not thick enough to change the classification. Depositional phases of the buried soil may be recognized:

- *Overblown:* A recent deposit of wind-blown material on the surface of an older soil can be identified consistently throughout the area and is thick enough to influence use, management, or behavior.

- *Wind hummocky:* Recent wind-laid deposits form a fine pattern of hummocks that markedly alter management requirements of the soil. The original soil is identifiable throughout most of the area, though it is covered in spots.

- *Overwash:* Material deposited by water contrasts with the underlying soil and is thick enough to influence management requirements significantly. Ordinarily, overwash phases are not used for very young alluvial soils having weakly expressed genetic horizons.

Texture terms in map unit names describe the material currently at the surface. Terms designating a depositional phase follow the term for texture class: *Alpha loamy sand, overblown, 2 to 8 percent slopes.*

Phases may be recognized for soils covered by a thin layer of volcanic ash: *Alpha loam, volcanic ash cover.* Such phases are generally used only if needed to distinguish the phase from another phase that lacks the ash cover.

A.4 Phases for Rock Fragments

A.4.1 Definition of Rock Fragments

Rock fragments are unattached pieces of rock 2 mm in diameter or larger. Rock fragments influence moisture storage, infiltration, runoff, and land use. They protect fine particles from washing and blowing. They dilute the volume of soil material that roots can penetrate and that provides nutrients to plants. Rock fragments do not break down after overnight shaking in a weak solution of sodium hexametaphosphate.

Rock fragments are described in terms that characterize their size and shape and, for some, the kind of rock. There are several classes: *pebbles, cobbles, channers, flagstones, stones,* and *boulders.* The terms are defined in Table A.1 according to their shape and size limits. If a size or range of sizes predominates, it is stated: "fine pebbles", "cobbles 10 to 15 cm in diameter", "channers 25 to 50 mm long". Boulders are more than 60 cm and mostly less than 3 m in diameter but include large glacial erratics 10 m or more long.

Gravel is a collection of pebbles, as in "outwash gravel". A single piece is a *pebble.* The terms "pebble" and "cobble" are usually restricted to rounded or subrounded fragments but can be used to describe angular fragments if they are not flat.

Words like chert, slate, and shale refer to a kind of rock, not a piece of rock. If

significant to classification or interpretation, the composition of the fragments can be given: "chert pebbles", "limestone channers".

Most of the size limits of the various classes conform to established conventions. The 2-mm lower limit of rock fragments is the upper limit of sand. The 76-mm upper limit of gravel is about the size of the 3-inch sieve (7.6 cm) used by many engineers as the upper limit of the base on which percentages of particles of different sizes (grain-size distribution) are based. The 5-mm and 20-mm divisions separating fine, medium, and coarse gravel are about the sizes of openings in the "number 4" screen (4.76 mm) and the "3/4 inch" screen (19.05 mm) used in engineering to separate fractions of rock fragments. The 250-mm limit corresponds approximately to the 10-inch limit that has been used conventionally to separate cobbles from stones. The limits for flat fragments, 150 mm and 380 mm, follow conventions used for many years to adjust for the relationships of thin, flat shape to volume, compared to roughly spherical fragments, and the differences of limitation for use imposed by different shapes of fragments.

A.4.1.1 Rock Fragments in the Soil

The volume of rock fragments is estimated in the field. The adjective form of a class name of rock fragments (Table A.1) is used as a modifier of the textural class name: "gravelly loam". The following classes are used.

- *Less than 15 percent by volume:* No special term is used; or "nongravelly" is used in writing for contrast with soils having more than 15 percent pebbles, cobbles, or flagstones.

- *15 to 35 percent by volume:* The adjective term of the dominant kind of rock fragment is used as a modifier of the textural term: "gravelly loam", "channery loam", "cobbly loam".

- *35 to 60 percent by volume:* The adjective term of the dominant kind of rock fragment is used with the word "very" as a modifier of the textural term: "very gravelly loam", "very flaggy loam".

- *More than 60 percent by volume:* If enough fine earth is present to determine the texture class (approximately 5 percent or more by volume) the adjective term of the dominant kind of rock fragment is used with the word "extremely" as a modifier of the textural term: "extremely gravelly loam". If there is too little fine earth to determine the texture class (less than about 5 percent by volume) the terms "gravel", "cobbles", "stones", and "boulders" are used in the place of fine earth texture.

The class limits apply to the volume of the layer occupied by *all pieces* of rock fragments larger than 2 mm but less than 25 mm, if rounded, or 38 mm long, if flat. Total volume of rock fragments in each layer is estimated, and the size class that makes up the greatest volume is used as the modifier. Usually the soil also contains fragments smaller or larger than those identified in the term. For example, a cobbly loam usually contains pebbles, but "gravelly" is not mentioned in the name.

More precise estimates of the amounts of coarse rock fragments than are provided by the defined classes are needed for some purposes. If the more precise information is needed, estimates of percentages of each size class or a combination of size classes are included in the description: "very cobbly loam; 30 percent cobbles, and 15 percent gravel" or "silt loam; about 10 percent gravel".

If loose pieces of rock are significant in use and management of a soil, they are bases of phase distinctions among map units. Exposed bedrock is not soil and is separately identified in mapping.

The volume occupied by individual pieces of rock can be seen and their aggregate volume percentage can be calculated. For some purposes, volume percentage must be converted to weight percentage.

A.4.1.2 Stones and Boulders on the Surface

Rock fragments on the surface of a soil, including both those that lie on the surface and those that are partly within the soil but protrude above ground[2], have important effects on soil use and management. The

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2. These terms are defined in Table A.2

Table A.1. Terms for rock fragments

Shape[1] and size	Noun	Adjective
Rounded, subrounded, angular, or irregular:		
2-7.6 cm diameter.......	Gravel[2]	Gravelly.
0.2-0.5 cm diameter.....	Fine gravel.....	Fine gravelly.
0.5-2 cm diameter.......	Medium gravel...	Medium gravelly.
2-7.6 cm diameter.......	Coarse gravel...	Coarse gravelly.
7.6-25 cm diameter......	Cobble...........	Cobbly.
25-60 cm diameter.......	Stone............	Stony.
> 60 cm diameter........	Boulder..........	Bouldery.
Flat:		
0.2-15 cm long..........	Channer..........	Channery.
15-38 cm long...........	Flagstone.....	Flaggy.
38-60 cm long...........	Stone............	Stony.
> 60 cm long............	Boulder..........	Bouldery.

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1. If significant to classification or interpretation, the shape of the fragments is indicated: "angular gravel", "irregular boulders".

2. A single fragment is called a "pebble".

limitations they impose are related to their number, size, and spacing at the surface.

The class limits that follow are given in terms of the approximate amount of stones and boulders at the surface.

- *Class 1:* Any stones or boulders cover less than 0.1 percent of the surface. Stones of the smallest sizes are at least 8 m apart; boulders of the smallest sizes are at least 20 m apart.

- *Class 2:* Stones or boulders cover about 0.1 to 3 percent of the surface. Stones of the smallest sizes are no less than 1 m apart; boulders of the smallest size are no less than 3 m apart.

- *Class 3:* Stones or boulders cover about 3 to 15 percent of the surface. Stones of the smallest size are as little as 0.5 m apart; boulders of the smallest size are as little as 1 m apart.

- *Class 4:* Stones or boulders cover about 15 to 50 percent of the surface and are so closely spaced that in most places it is possible to step from stone to stone or jump from boulder to boulder without touching the soil. Stones of the smallest size are as little as 0.3 m apart; boulders of the smallest size are as little as 0.5 m apart.

- *Class 5:* Stones or boulders appear to be nearly continuous and cover about 50 to 90 percent of the surface. The distances between stones or boulders are measured in centimeters or decimeters in most places. Stones of the smallest size are as little as 0.01 m apart; boulders of the smallest size are as little as 0.03 m apart. Classifiable soil is among the rubble, and plants can grow if moisture and nutrients are available.

- *Class 6:* Stones or boulders cover more than 90 percent of the surface, and so little earthy material is between the stones or boulders that few plants other than lichens can grow even though other factors are favorable. The deposits are not classifiable as soil and are mapped as "rubble land".

Table A.2. Classes of stoniness and boulderiness in relation to surface coverage and spacing between fragments

Class	Percentage of surface covered	Distance between stones or boulders if their diameter is: 25 cm	60 cm	120 cm
		meters	meters	meters
	< 0.1	> 8	> 20	> 37
2	0.1-3	1-8	3-20	6-37
3	3-15	0.5-1	1-3	2-6
4	15-50	0.3-0.5	0.5-1	1-2
5	50-90	0.01-0.3	0.03-0.5	0.07-1
6	> 90	-	-	-

These limits are intended only as guides to amounts that may mark critical limitations for major kinds of land use. The classes are used in writing about soils and in conversation to convey concepts of the surface condition of areas of soil. Table A.2 is a summary of the classes and a guide to the amount of stones and boulders in each.

A.4.2 Rock Fragment Phases Descriptions

Rock fragments on the surface and in the surface layer are commonly used as phase distinctions. Kinds of rock fragments are defined by shape and size in Table A.1. The classes are helpful in describing soil phases, but phase limits are set to make the distinctions that are important for the survey, whether or not the phase limits correspond with standard class limits.

The discussion that follows is applicable to arable soils. For other uses--such as forestry, range, or recreation--the sizes, shapes, amounts, and mixtures of rock fragments have different significance. For example, gravel, cobbles, and stones influence forestry much less than they do cultivation, although they could affect access and reforestation.

The flexible class limits provide some opportunity to adjust phase limits within the definitions of the classes, but phase limits are set to make the distinctions that are important for the survey, whether or not they correspond with class limits. The effect of 20 percent fine gravel on the use of a soil, for example, is quite different from the effect of 20 percent flagstones.

The definitions of the smaller rock fragments that follow accommodate the most detailed phase distinctions that can ordinarily be made accurately by field methods. The term "gravelly" is used in the examples of names that follow, but names of each of the other kinds of rock fragments may be substituted as appropriate. For example, other kinds of rock fragments smaller than stones, such as cobbly or channery, are substituted as appropriate[3]. The phase limits may differ for larger fragments.

- *Slightly gravelly:* The surface layer contains enough pebbles to affect special uses that tolerate few if any rock fragments, but the pebbles do not interfere significantly with tillage of field crops such as corn. The volume is usually less than 15 percent. A slightly gravelly phase can be recognized for soils that are used for special purposes, such as growing turf.

- *Gravelly:* The surface layer contains enough pebbles to interfere with tillage of common field crops, but most tillage is performed in the same manner and with the same equipment as on soil free of fragments. The pebbles are a nuisance. They cause some equipment

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3. Modifiers such as "cindery" or "very cindery" may be used where necessary.

breakage but few major delays in field operations. The volume of pebbles is usually between 15 and 35 percent but may be less if the fragments are large or more if they are small.

- *Very gravelly:* The surface layer contains enough pebbles to interfere seriously with tillage of common field crops, to damage equipment, and to decrease the rate of most field operations. The quality of tillage operations is affected. The kinds of crops that can be grown is restricted, the precision of planting and of fertilizer placement is reduced, and young plants are frequently covered during tillage. The volume of pebbles is usually between 35 and 60 percent.

- *Extremely gravelly:* The surface layer contains so many pebbles that tillage of common field crops is often impractical, though not necessarily impossible. Tillage implements must force their way through a mass of pebbles that have fines between them. The volume of pebbles is usually more than 60 percent (Figure A.2)

The rock fragments in the surface layer commonly span two or more size classes and may include fragments of more than one shape. The name of the kind of fragment that is judged most important in limiting the management of the soil is used in the phase designation. Usually, the largest fragments that are present in significant amounts are most important. A soil having enough cobbles in or on the surface layer to impose important restrictions on soil use, for example, is named "cobbly" even though the soil also contains as much or more gravel. Both terms are not used. Terms for the three size classes of gravel (fine, medium, and coarse) are not used in phase names unless the pebbles are well sorted into one of the narrowly defined size fractions. The term "gravelly" is commonly used as a general term even though one size may be dominant. Some soils do have pebbles almost entirely within the 2 to 5 mm size class. The uniformly fine size of the pebbles may be important enough for some purposes to identify in the name.

Classes of stoniness and boulderiness are also used to define phases of rock fragments on the surface. The classes are given following the description of phases. The following phases of the larger rock fragments represent about the maximum detail that can be mapped consistently in most soil surveys. "Bouldery" is substituted for "stony" as appropriate.

- *Stony*: The areas have enough stones at or near the surface to be a continuing nuisance during operations that mix the surface layer, but they do not make most operations of these kinds impractical. Conventional wheeled vehicles can move with reasonable freedom over the area. Stones might damage equipment that mixes the soil and vehicles that move on the surface. Usually these areas have class 2 or 3 stoniness. If necessary in a highly detailed survey, class 2 may be designated as "slightly stony" and class 3 as "moderately stony".

- *Very stony*: The areas have so many stones at or near the surface that operations which mix the surface layer either require heavy equipment or use of implements that can operate between the larger stones. Tillage with conventional powered farm equipment is impractical. Wheeled tractors and vehicles with high clearance can operate on carefully chosen routes over and around the stones. Usually these areas have class 4 stoniness.

- *Extremely stony*: The areas have so many stones at or near the surface that wheeled powered equipment, other than some special types, can operate only along selected routes. Tracked vehicles may be used in most places, though some routes have to be cleared. Usually these areas have class 5 stoniness.

- *Rubbly*: The areas have so many stones at or near the surface that tracked vehicles cannot be used in most places. Usually these areas have class 6 stoniness.

A.5 Rockiness

Where rock outcrops cover 10 percent or less of the delineations a "rocky" phase may be needed. Where the area is more than 10 percent rock outcrop, the map units are named as complexes or associations of soils and rock outcrop.

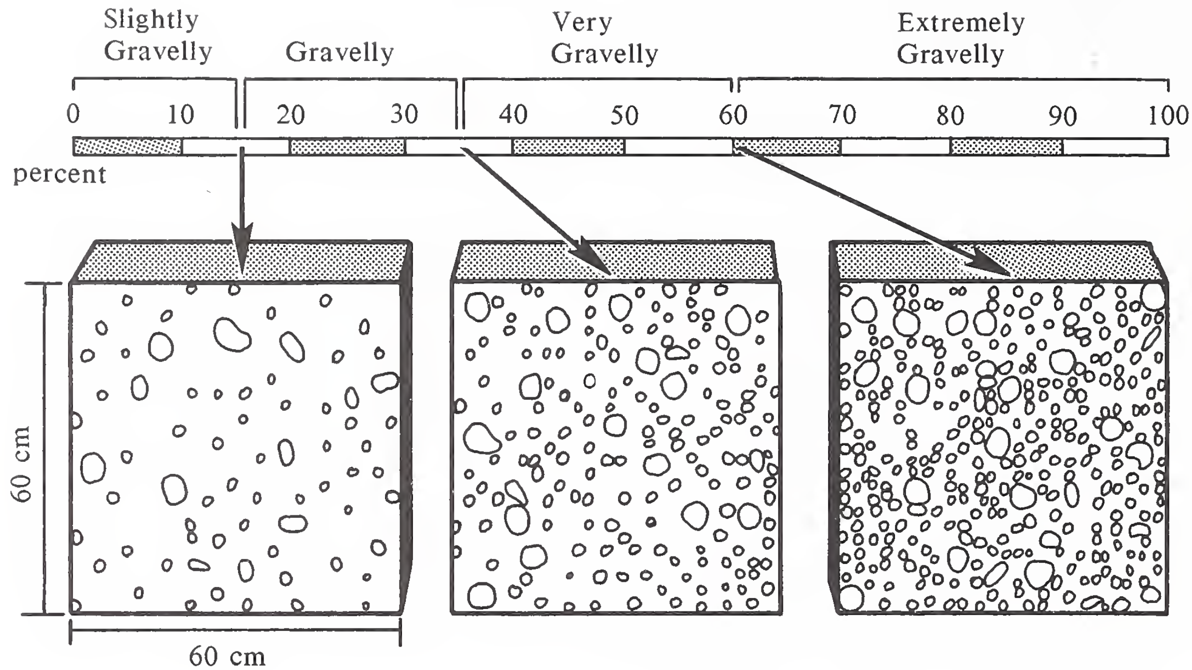

Figure A.2: Separation points within the gravelly phase.

In recognizing phases, area is only one consideration. If only one phase is needed, it is designated "rocky": *Alpha loam, rocky.* If size, spacing, and other features of the rock-soil relationship are significant to use or management of the map unit, phases designated as "slightly rocky", "rocky", and "very rocky" can be used.

A.5.1 Classes Used for Rock Outcrops

Rock outcrops are exposures of bedrock. Most outcrops are too hard to be broken and mixed by tillage. The exposures are presumed to be a part of a large body of underground bedrock; rock fragments are discrete pieces of rock and are not attached to the bedrock.

In some places, bodies of rock 100 m or more in diameter are detached from any extensive continuum of bedrock and may have been displaced; however, whether or not such bodies are detached or displaced is not readily observable and for most purposes is not important. Bodies of rock this large are treated as bedrock. For bodies about the size of a pedon, a distinction between detached fragments and exposed rock outcrop is more meaningful. Generally, bodies of rock that have few cracks in which plants can grow and that appear to be displaced little are treated as rock outcrop if they are as large as a pedon. However, bodies up to 10 meters or more across that are clearly detached and displaced, such as large glacial erratics, are described as boulders.

The effects of rock outcrop on land use depend on the part of an area occupied by outcrops, the size and spacing of the outcrops, the manner in which the outcrops protrude above the surface of the surrounding soil, the kind of land use, the technology employed in using the land, and the properties of the soil between the outcrops. The area occupied by outcrops, by itself, is not the most useful criterion of the significance of rock outcrop. The spacing of outcrops determines how often operation of equipment across an area is interrupted, the efficiency of operations, the probability of equipment breakage, and the like. The manner in which outcrops protrude above the surrounding soil surface affects the kinds of equipment that can be used and the routes of movement. These properties, as well as the properties of the surrounding soil, are described when a site is surveyed.

Classes of areas of rock outcrop, including soil supporting little or no vegetation, are as follows:

Class 1: Less than 0.1 percent of the surface is exposed bedrock.

Class 2: 0.1 to 2 percent of the surface is exposed bedrock.

Class 3: 2 to 10 percent of the surface is exposed bedrock.

Class 4: 10 to 25 percent of the surface is exposed bedrock.

Class 5: 25 to 50 percent of the surface is exposed bedrock.

Class 6: 50 to 90 percent of the surface is exposed bedrock.

Class 7: More than 90 percent of the surface is exposed bedrock.

A.6 Slope Phases

The slope range of some soil taxa is narrow; in others it is wide enough to include differences that are important for soil use and management. Slope phases are used to divide soil series or other taxa as may be needed for the purposes of the survey.

Slope gradient, complexity, shape, length, and aspect are all potential bases for phase distinctions. By far the most commonly used is gradient. Complexity is also used in many surveys. Slope classes are useful for describing soil phases but are not themselves the equivalents of phases. Flexible class limits permit adjusting phase limits within the definitions of the classes, but phase limits are set to make the distinctions that are important for the survey, whether or not they correspond with class limits. Slope length can often be appraised directly from delineations on the map, and in many cases the significance to use and management of slope length depends on the kind of landscape in which the soil occurs. Shape is seldom used as a phase distinction; differences in shape are commonly related to differences in internal properties that distinguish taxa. Slope aspect is used mainly in high latitudes. If aspect is used as a phase criterion, its name follows any other slope terms that may be used: *25 to 40 percent north slopes (or north-facing slopes).*

Phases defined on the basis of slope should fit the landscape. They should be so distinct that they can be identified and mapped consistently. They should not add complexity to the map without improving its usefulness. And most importantly, they should separate areas that have significant differences in suitability or management needs.

A uniform system of slope classes should not be used indiscriminately as the basis for differentiating phases. Slope phases that have narrow ranges in gradient may be needed for soils that have other properties favorable to intensive use. However, in other survey areas, slope phases having equally narrow ranges may complicate legends and maps without making useful separations if the soil has other major limitations for use. A nonstony, highly productive soil may justify map units having narrow slope ranges for predictions about soil management for cropping, whereas one that is too stony for cropping, though otherwise similar, may justify only very broad slope ranges. The specific limits of gradient between phases vary among different kinds of soil. In each soil survey, adjustments are made in slope phases on the basis of data or experience, indicating that one set of limits and ranges makes a more useful distinction for the objectives than another for each kind of soil. Slope phases are named and used to separate map units if the slope range exceeds that of a single use and management class.

In each survey, the limits of slope phases are based on data or experience indicating that this set of limits makes the most useful distinctions for each kind of soil. Range in the slope of a phase of one series may encompass the ranges of two or more phases of another series. A single set of slope classes that would serve as phase distinctions for all soils is impractical because of the varied relationship of slope to mappable landscapes and the many and varied relationships of slope to the use and management of different kinds of soils.

Slope phases can be named either by numerical slope gradient limits, with or without designations of complexity, or by descriptive terms. Slope terms for map units for taxa above the series are generally given in descriptive terms. The word "slopes" is used if gradient is specified as a percentage but is omitted if descriptive terms are used. The slope phase designation follows the name

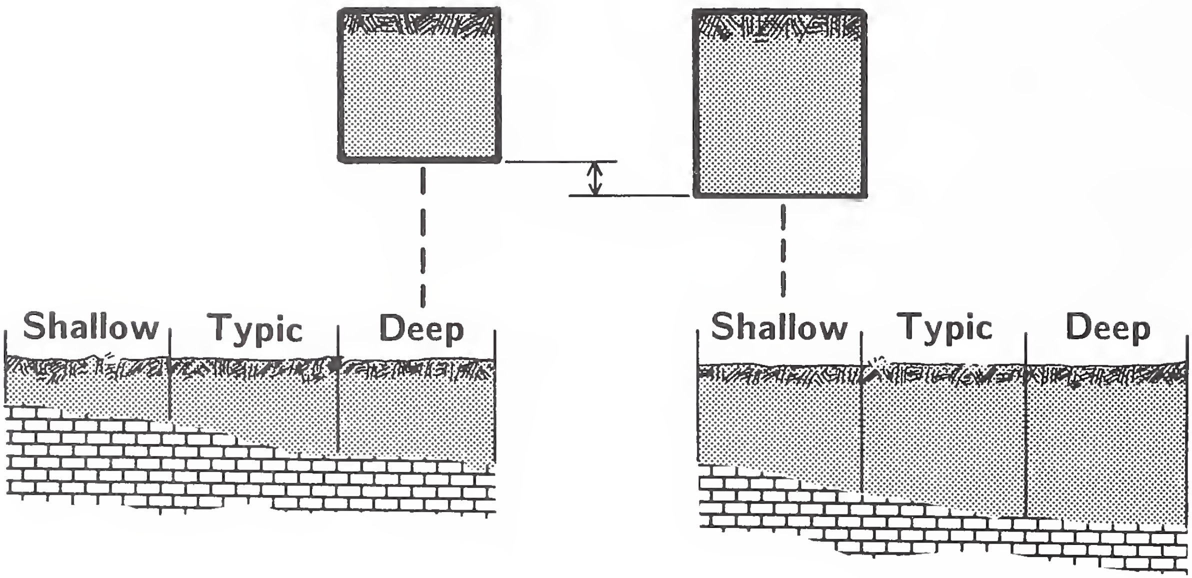

Figure A.3: Depth phases are relative to the individual soil. The deep phase of one soil may be shallower than the shallow phase of another soil.

of the taxon and the terms for phases based on internal soil properties: *Beta gravelly loam, 8 to 16 percent slopes; Beta gravelly loam, strongly sloping; Beta gravelly loam, thick solum, 8 to 16 percent slopes; Beta soils, rolling; Gamma family, hilly.*

A.7 Depth Phases

Soil depth phases are used where variations in depth to a contrasting layer are significant to soil use, management, or behavior. Terms for depth classes are generally used in naming phases, but modifications are needed in some areas. For instance, the class "moderately deep", ranging from 50 to 100 cm, may be too broad to satisfy the objectives of some surveys. This range can be divided, with perhaps one class ranging in depth from 50 to 75 cm and the other from 75 to 100 cm, if the more narrowly defined phases occur in a consistent pattern within the survey area and can be mapped. Generally the phase that covers more acreage is not given a depth designation. If that is the deeper phase, "moderately shallow" is used to designate the phase that has a depth range of 50 to 75 cm. If the shallower phase is more extensive, "moderately deep" is used to designate the 75 to 100 cm phase.

In some surveys, using the standard class terms may be misleading. For example, if a series that is normally more than 150 cm deep to bedrock has a phase that is 100 to 150 cm deep, calling the less extensive phase "deep" could be construed to mean that the phase is deeper than normal. In such cases, depth limits can be specified in the phase name *Alpha loam, 100 to 150 cm deep* or substratum phase terminology can be used instead (Figure A.3).

A.7.1 Depth to Restricting and Contrasting Layers

Depth to restricting or contrasting layers is important to water- and nutrient-supplying capacity, downward movement of water, root penetration, and the like. Depth to and kind of material can have an important effect on how a soil behaves when used for various

purposes and on how it responds to management. The range of depth is defined for each soil. The limits that are significant differ depending on the other soil characteristics.

In descriptions of depth, the nature of the restricting or contrasting layer is specified. If the nature of the contrasting layer is not given, it is understood to be consolidated bedrock.

Depth to a restricting or contrasting layer is measured from the soil surface. For soils with an O horizon that has never been saturated for prolonged periods, the soil surface is the top of the part of the O horizon that has decomposed so much that most of the original material cannot be recognized with the naked eye. If the uppermost horizon is an O horizon that is or has been saturated for prolonged periods, the soil surface is the top of that horizon. Otherwise, the soil surface is the top of the mineral soil.

So that the terms used to indicate depth will have approximately the same meaning everywhere, the following classes are suggested:

Very shallow---------Less than 25 cm
Shallow--------------25 to 50 cm
Moderately deep------50 to 100 cm
Deep-----------------100 to 150 cm
Very deep------------More than 150 cm

The terms "very shallow", "shallow", etc. as used in conversation and in writing about soil depth do not necessarily carry these definitions. The upper and lower limits given are guidelines. Any of the terms may be used to name ranges in depth that differ somewhat from the limits shown, but unless different ranges are specified these approximate depths are understood.

A.8 Substratum Phases

Where underlying material contrasts sharply with the material above and interpretations are affected, substratum phases are used. The kind of contrasting material is indicated in the name of the map unit. The terms that follow have been used to identify substratum phases: *calcareous substratum, chalk substratum, clay substratum, gravelly substratum, gypsiferous substratum, lacustrine substratum, marly substratum, sandy substratum, silty substratum, shale substratum, till substratum.* These terms are descriptive, not mutually exclusive. Other terms can be used as appropriate. The identifying term follows the name of the taxon and any designation for surface texture and precedes any term for slope or erosion in the phase name: Plano silt loam, gravelly substratum, 6 to 20 percent slopes.

Where there is a choice between using a depth phase or a substratum phase to identify a map unit, a depth phase is generally used if the contrasting layer is bedrock.

A.9 Soil Water Phases

Phases are used to distinguish differences in soil water state, water table level, drainage, and the like where the series range in one or more of these properties need to be divided for purposes of the survey. Significant differences in these factors are commonly reflected in differences in soil morphology and are distinguished at the series level. In some soils, however, evidence of wetness, such as gray color or mottling, does not fully reflect the natural drainage or wetness of the soil. Such soils may not be differentiated at the series level with the refinement needed for the purposes of the survey.

Phases commonly used include *high water table, moderately deep water table, poorly drained, slightly wet, moderately wet, wet, ponded, and drained.* Some soils have properties that reflect former wetness but have been drained artificially; "drained" phases can be used to separate drained areas from undrained. In other soils a water table fluctuates below the depth where properties are criteria for defining series; "water table" phases can be used to identify such soils.

A.10 Salinity Phases

Saline phases are used to distinguish between degrees of salinity that are important for soil use or management. Electrical conductivity values and observations of plant growth are guides for recognizing phases.

Table A.3. Salinity classes

Class	Electrical conductivity (S/m)
0. Non saline	0.0-0.2
1. Very slightly saline	0.2-0.4
2. Slightly saline	0.4-0.8
3. Moderately saline	0.8-1.6
4. Strongly saline	> 1.6

Designation of salinity phases depends on the various uses likely to be made of the soils and the effect of excessive amounts of salt on those uses. In farming areas the crops most likely to be grown must be considered. Management induced salinity that fluctuates widely with management practices generally would not be a basis for phase distinctions.

Vegetation, especially the native cover, often shows the location of saline soils and their boundaries. Using vegetation along with land form and other features as guides and correlating these field observations with laboratory or field analyses of soil samples, the surveyor can usually draw boundaries with reasonable accuracy. However, plants vary in their tolerance of salt by species, variety, and age, and perhaps other factors. Some plants are not good indicators of salinity because they grow well whether salts are present in excessive amounts or not.

Other problems must also be considered in designating salinity phases. Different kinds of salts and combinations of salts have varied effects on soil behavior. In many soils salts are transitory; in others they are permanent. Excessive sodium may or may not be associated with excess salinity.

The electrical conductivity of a saturation extract is the standard measure of salinity. Electrical conductivity is related to the amount of salts more soluble than gypsum in the soil, but it may include a small contribution (up to 0.22 S/m)[4] from dissolved gypsum.

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4. One siemens (S) = one mho; millimhos cm^{-1} = S m^{-1} x 10

If it has been measured, the electrical conductivity (in siemens per meter corrected to a temperature of 25° C) is reported in soil descriptions. Classes of salinity are used (see Table A.3) if the electrical conductivity has not been determined but salinity is inferred.

The following classes of salinity (Table A.3), *which are a general guide to naming phases*, refer to the presence of salts anywhere in the soil.

- *Non saline*: Effects of salinity on plant growth are negligible. Salinity is mainly class 1. "Non saline" is omitted from the names of map units unless the soil taxon is typically saline. A very slightly saline phase may be useful in some surveys where crops extremely sensitive to salts are grown or are likely to be grown.

- *Slightly saline*: Growth of many plants is affected. Yields of such plants as bromes, sunflower, corn, and peas are reduced seriously. Western wheatgrass, kale, and barley are affected little. Salinity is mainly class 2.

- *Moderately saline*: Only plants tolerant of salinity, such as western wheatgrass, beets, and barley, grow well, and yields of these are commonly reduced. Salinity is mainly class 3.

- *Strongly saline*: Only the most tolerant halophytic plants, such as saltgrass, grow well. Salinity is mainly class 4.

Terms for saline phases follow terms for surface texture in phase names: *Alpha silt loam, strongly saline.*

A.11 Sodicity Phases

The sodium adsorption ratio (SAR) is the standard measure of the sodicity of a soil. The sodium adsorption ratio is calculated from the concentrations (in milliequivalents per liter) of sodium, calcium, and magnesium in the saturation extract:

$$SAR = Na^{+}/\sqrt{Ca^{+2} + Mg^{+2}/2}$$

Formerly, the exchangeable sodium percentage, which equals exchangeable sodium (meq/100g soil) divided by the cation exchange capacity (meq/100g soil) times 100, was the primary measure of sodicity. The test for exchangeable sodium percentage, however, has proved unreliable in soils containing soluble sodium silicate minerals or large amounts of sodium chloride.

Sodium is toxic to some crops, such as avocados and other fruit trees. More importantly, sodium affects the soil's physical properties, mainly permeability. A sodic condition has little effect on permeability in highly saline soils. A soil that is both saline and sodic may, when artificially drained, drain freely at first; but after some of the salt has been removed, further leaching of salt becomes difficult or impossible. The sodium adsorption ratio usually decreases as a soil is leached, but the amount of change depends in part on the composition of the water used for leaching and therefore cannot be predicted with certainty. If the initial sodium adsorption ratio is greater than 10 and the initial electrical conductivity is more than 2 S/m and information is needed as to whether the soil will be sodic following leaching, the sodium adsorption ratio is determined on another sample following leaching with the intended irrigation water. For the classification of soils with an electrical conductivity of more than 2 S/m the sodium adsorption ratio determined after leaching with distilled water to an electrical conductivity of about 0.4 S/m is used. The amount of amendments such as gypsum needed to reclaim a sodic soil depends in part on the sodium adsorption ratio and in part on the cation exchange capacity of the soil. If the cation exchange capacity is not known, a gypsum requirement test is useful.

For some soils, recognizing a "sodic" phase is useful. The term "sodic" is used as a phase designation, if needed, generally without terms for degrees of sodicity: *Alpha loam, sodic, 0 to 3 percent slopes.*

A.12 Physiography Phases

Land form or physiographic position may be used as a phase criterion to distinguish phases of a single taxon. A soil in a deposit of loess 3 meters thick on a terrace, for example, may be so much like a soil in a similar deposit on a till plain that the two are members of the same series. For some uses, however, the two soils need to be distinguished on the map. A physiographic phase can be used to identify the less extensive soil.

The following terms are examples that have been used to designate physiographic phases: *bench, depressional, fan, karst, ridge, and terrace.* The terms are usually used to identify phases that differ in position from that typical for the soil. The typical physiography is not given in a phase name. The physiographic phase designation follows the term for surface texture and precedes any terms for slope or erosion: *Tioga gravelly loam, fan, 0 to 8 percent slopes.*

A.13 Erosion Phases

A.13.1 Accelerated Erosion

Accelerated erosion and natural erosion are so intimately interrelated in some cultural landscapes that distinguishing them is difficult. Natural erosion is an important process that affects soil formation, and like man-induced erosion may remove all or part of soils formed in the natural landscape.

The processes of erosion influenced by man can be divided into two classes, water erosion and wind erosion,[5] according to the moving agent.

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5. "Wind erosion" is sometimes used for the sculpture of rocks by wind-blown particles. The term is used in these guidelines, in soil science generally, and by many geologists for the detachment, transportation, and deposition of soil particles by wind.

A.13.1.1 Water Erosion

Water erosion results from disturbance of the soil surface by flowing water and the material it carries. A part of the process is the detachment of soil particles by the impact of raindrops. The particles are suspended in runoff water and carried away. Three kinds of accelerated water erosion are commonly recognized: sheet, rill, and gully. These are distinguished by the relative depth and stability of the channels cut by running water.

Sheet erosion

Sheet erosion is the more or less uniform removal of soil from an area without the development of conspicuous water channels. The channels are tiny or tortuous, exceedingly numerous, and unstable; they enlarge and straighten as the volume of runoff increases. Sheet erosion is less apparent, particularly in its early stages, than other types of erosion. It can be serious on some soils having a slope gradient of only 1 or 2 percent. It is generally more serious as slope gradient increases.

Rill erosion

Rill erosion is the removal of soil through the cutting of many small but conspicuous channels where runoff concentrates. Rill erosion is intermediate between sheet and gully erosion. The channels are shallow enough that they are easily obliterated by tillage; thus, after an eroded field has been cultivated, determining whether the soil losses resulted from sheet or rill erosion is generally impossible.

Gully erosion

Gully erosion is conspicuous. Gullies form where water concentrates and flows as a stream, cutting down into the soil along the line of flow. Gullies form in exposed natural drainageways, in plow furrows, in animal trails, in vehicle ruts, between rows of crop plants, and below broken man-made terraces. In contrast to rills, they cannot be obliterated by ordinary tillage. Deep gullies cannot be crossed with common types of farm equipment.

Gullies and gully patterns vary widely in different kinds of soil and on different landforms. In some places, a single gully forms in a field; in other places, gullies are closely spaced leaving little or no unaffected surface between them. V-shaped gullies cutting into the soil more or less uniformly throughout their courses are most common. These form in material that is equally or increasingly resistant to erosion with depth. U-shapped gullies form in material that is equally resistant or decreases in resistance to erosion with depth, as where the water cuts through coherent upper material into a loose, incoherent substratum. As the substratum is washed away, the overlying material loses its support and falls into the gully to be washed away. Most U-shaped gullies become modified toward a V shape once the channel stabilizes and the banks start to spall and slump.

A.13.1.2 Wind Erosion

Wind is not generally an important cause of erosion in humid areas except on unprotected sandy soils and on tracts of drained and cultivated organic soils. In regions of low rainfall, wind erosion can be widespread, especially during periods of drought. Unlike water erosion, wind erosion is generally not related to slope gradient. The hazard of wind erosion is increased by removing or reducing the vegetation.

When winds are strong, the finer particles are swept into the air and may be carried for great distances. Some circle the globe at very high elevations. Coarser particles are rolled or swept along on or near the soil surface, kicking finer particles into the air, and are deposited in places sheltered from the wind. When wind erosion is severe the sand particles may drift back and forth locally with changes in wind direction while the silt and clay are carried away. *Blowouts*, spots from which the surface layer has blown away, may be associated with spots of deposition in such an intricate pattern that the two cannot be identified separately on soil maps.

A.13.1.3 Eroded Condition of Soils

The degree to which accelerated erosion has modified the soil is estimated during soil examinations. Mapping units are designed to record the condition of the remaining soil if it differs significantly in use, suitability, or management requirements from the uneroded soil. The definition of the soil in the

mapping unit and interpretations for mapped areas must focus on the properties of the soil that remains; properties of the material that has been lost can only be inferred and are not used to define or classify soils.

A.13.1.4 Estimating the Degree of Erosion.

To estimate the degree of accelerated erosion of a specific soil, the properties of the uneroded soil in a site and state of use comparable to those of the eroded soil are determined first, if possible. Then the properties of the eroded soil are determined. By comparing the two sets of properties, the degree to which erosion has modified the soil can be estimated. Parts of horizons or entire horizons and the thickness of surface layers that have been lost, the variations within mappable areas, and similar features can be estimated by comparing properties.

Estimates of erosion losses should not be confused with susceptibility to erosion. Kinds of soil may be grouped according to their susceptibility to erosion, but this is a different matter.

Classes of water and wind erosion based on estimated soil losses are useful for some purposes, such as evaluating the amount of degradation on the soil resource that has occurred or characterizing soil areas in terms of effects of erosion on soil morphology. Field notes record whether erosion was caused by water or wind.

A.13.1.5 Classes of Accelerated Erosion

Class 1: This class consists of soils that have lost some of the original A and/or E horizon but on the average less than 25 percent of the original A and/or E horizon or of the uppermost 20 cm if the original A and/or E was less than 20 cm thick. Throughout most of the area the thickness of the surface layer is within the normal range of variability of the uneroded soil. Scattered spots amounting to less than 20 percent of the area may be modified appreciably.

Evidence for class 1 erosion includes (1) a few rills, (2) accumulation of sediment at the base of slopes or in depressions, (3) scattered spots where the plow layer contains material from below the original plow layer, and (4) evidence of formation of widely spaced deep rills or shallow gullies without consistently measurable reduction in thickness or other change in properties between the rills or gullies.

Class 2: This class consists of soils that have lost on the average 25 to 75 percent of the original A and/or E horizon or of the uppermost 20 cm if the original A and/or E horizon was less than 20 cm thick. Throughout most cultivated areas of class 2 erosion the surface layer consists of a mixture of the original A and/or E horizon and material from below. Some areas may have intricate patterns ranging from uneroded spots to spots where all of the original A and/or E horizon has been removed. Where the original A horizon was very thick, little or no mixing of underlying material with the original A and/or E horizon may have taken place.

Class 3: This class consists of soils that have lost on the average 75 percent or more of the original A and/or E horizon or of the uppermost 20 cm if the original A and/or E horizon was less than 20 cm thick. In most areas of class 3 erosion, material below the original A and/or E horizon is exposed at the surface in cultivated areas. The plow layer consists entirely or largely of material that was below the original A and/or E horizon. Even where the original A and/or E horizon was very thick, at least some mixing of underlying material with the original A and/or E horizon has generally taken place.

Class 4: This class consists of soils that have lost all of the A and/or E horizon or the uppermost 20 cm if the original A and/or E horizon was less than 20 cm thick plus some or all of the deeper horizons throughout most of the area. The original soil can be identified only in spots. Some areas may be smooth, but most have an intricate pattern of gullies.

A.13.2 Erosion Phases Descriptions

Significant differences in a soil's potential for use, its management needs, or its performance may be brought about by accelerated erosion. Such differences are a basis for recognizing phases provided the taxonomic unit has not changed due to the accelerated erosion. Phases of eroded soil are identified on the basis of the properties of the soil that remains, although the amount of soil lost is estimated and noted.

Properties related to natural erosion are a part of the definition of a taxon, not bases for erosion phases. Erodibility, too, is an inherent quality of a soil and not itself a criterion for erosion phases.

Eroded phases are defined so the boundaries on the soil maps separate soil areas of unlike suitabilities and soil areas of unlike management needs and responses. If a tentative phase turns out to have nearly the same limitations, management needs, and responses to management as another phase of the same soil, the two are combined. The term designating the eroded soil phase is the last term in the phase name: *Alpha loam, 8 to 15 percent slopes, eroded.*

Guidelines for naming phases of soil eroded by water are as follows:

- *Slightly eroded:* Erosion has changed the soil enough to require only slight modification of management from that of the uneroded soil; potential use and management remain generally the same. Most slightly eroded soils have class 1 erosion. Slightly eroded areas are not distinguished from uneroded areas in most surveys.

- *Moderately eroded*: Erosion has changed the soil to such an extent that required management or the response to management differs in major respects from that of the uneroded soil. Suitabilities for major uses--such as field and horticultural crops, pasture, forestry, and major engineering uses--are the same. The distinction is made by comparing management and suitability of the eroded soil with those of the uneroded soil. In most moderately eroded soils ordinary tillage implements reach through the remaining A horizon, or well below the depth of the original plowed layer if the A horizon was originally less than 20 cm thick (class 2 erosion). Generally the plow layer consists of a mixture of the original A horizon and the underlying horizons. Most mapped areas of moderately eroded soils have patches in which the plow layer consists wholly of the original A horizon and others in which it consists wholly of underlying horizons. Shallow gullies may be present. The word "moderately" is omitted from the name unless it is needed to differentiate between this phase and other eroded phases of the same soil.

- *Severely eroded*: Erosion has changed the soil so much that (1) the eroded soil is suited only to uses significantly less intensive than the uneroded soil, such as use for pasture instead of crops, (2) the eroded soil needs intensive management immediately or over a long period to be suitable for the same uses as the uneroded soil, (3) productivity is reduced significantly, or (4) limitations for some major engineering interpretations are greater than on the uneroded soil. Severely eroded phases commonly have been eroded to the extent that the plow layer consists essentially of material from underlying horizons (class 3 erosion), though patches in which the plow layer is a mixture of the original A horizon and underlying horizons may be present within delineations. Shallow gullies, or a few deep ones, are common in some places.

If a soil has been so eroded that diagnostic soil horizons have been removed throughout most of the area (class 4 erosion), it is not recognized as an eroded phase of the taxon of the original soil. The original soil is no longer identifiable except in isolated spots; the current soil is placed in a taxonomic class based on the horizons and properties that remain. The unit is not designated as a phase of eroded soil either of the new taxon or of any taxon presumed to represent the soil before erosion. The soil is classified at the lowest level in which it can be placed in the taxonomic system. Similarly, if a soil has been eroded enough to change its classification, say from a Mollisol to an Alfisol, or an Inceptisol even if erosion is only within the range of class 1, it is given the name of a new taxon and is not an eroded phase.

Guidelines for designating phases of soil eroded by wind are as follows:

- *Eroded (blown)*: Wind has removed so much soil that required management differs significantly from that of the uneroded soil, but suitabilities for use remain the same. The term "moderately" is understood.

- *Severely eroded (severely blown)*: Wind has removed so much material or has shifted it from place to place within the area to such an extent that either the suitability for use is different from that of the uneroded soil or the soil of the area must be extensively reworked and management unlike that of the uneroded soil must be used for the soil to be suitable for the same uses.

Many areas identified as moderately and severely wind-eroded are, in fact, mixtures of small areas of uneroded soil and soil eroded to various degrees. The amount of erosion throughout a delineation can be described only in general terms.

If a soil has been so eroded by wind that genetic soil horizons have been removed throughout most of the area it is not identified as a phase of eroded soil; rather it is classified in another taxon.

A.14 Thickness Phases

The solum and the various horizons in soil have characteristic ranges in thickness for each taxon. Thickness phases are used to divide the range of thickness of the solum or of the upper horizons if mappable areas of one such phase differ consistently from areas of the other phase and require different interpretations for the purposes of the survey. Phases are not used to differentiate thickness of the subsoil or the substratum. Four thickness phases are used:

1. *Thick surface*: The thickness of the A horizon or of the A and E horizons combined is within the thickest half of the range for the taxon.

2. *Thin surface*: The thickness of the A horizon or of the A and E horizons combined is within the thinnest half of the range for the taxon.

3. *Thick solum*: The thickness of the solum is within the thickest half of the range for the taxon.

4. *Thin solum*: The thickness of the solum is within the thinnest half of the range for the taxon.

A term is used for the less extensive of two thickness phases. For example, most delineations of a given soil may have an A horizon that is mainly between 25 and 35 cm thick (though the A horizon of some pedons in these delineations is 40 cm thick). If the A horizon is mainly 35 to 40 cm thick in other delineations of the same soil and the difference is significant for purposes of the survey, a thick-surface phase can be recognized. The phase in which the A horizon is dominantly 25 to 35 cm thick is the norm; thickness of the A horizon is described for this phase but is not identified in the name.

The thickness term follows any terms for surface texture and precedes any terms for slope or erosion: *Brownfield fine sand, thick surface, 0 to 3 percent slopes.*

A.15 Climate Phases

Climate can be used both for phase distinctions and for area distinctions.

In some places, especially in mountainous or hilly areas, precipitation or air temperature can differ greatly within short distances, yet these differences may not be reflected in internal properties of the soil. Air drainage can differ enough from one location to another to produce a difference in the dates of the last killing frost in the spring or the first in the fall, or one area may be frost free. Where differences of this kind are significant for the purposes of the survey and can be identified and mapped consistently, climatic phases or areas are used.

Only two climatic conditions are recognized for a given taxon: (1) the common climate, the climate that influences the greatest extent of the taxon, from which the climate designation is omitted, and (2) a departure from the common climate, for which a climatic designation is used. The departure may be in either of two directions from the norm: *warm* or *cool; high precipitation* or *low precipitation*. Each of the terms is connotative only in reference to the common climate of the taxon and must be described specifically for each phase to which it is applied. The appropriate term follows texture: *Alpha sandy loam, cool.*

Climatic phases are only used where temperature or precipitation differs markedly between parts of a survey area.

APPENDIX B

Kinds of Miscellaneous Areas

Following are discussions of recognized kinds of miscellaneous areas.

Badland is moderately steep to very steep barren land dissected by many intermittent drainage channels. The areas are ordinarily not stony. Badland is most common in semiarid and arid regions where streams cut into soft geologic material. Local relief generally ranges between 10 and 200 meters. Potential runoff is very high, and erosion is active. Small inclusions of identifiable soils may support vegetation of very limited value for grazing.

Beaches are sandy, gravelly, or cobbly shores washed and rewashed by waves. The areas may be partly covered with water during high tides or storms.

Blownout land consists of areas from which all or most of the soil material has been removed by extreme wind erosion. The land is essentially barren. The areas are generally shallow depressions that have flat or irregular floors. In some places the floor is a layer of material that is more resistant to wind than the removed material or is a layer of pebbles or cobbles; or the floor may have been formed by exposure of the water table. Areas covered by water most of the year are mapped as "Water". Some areas have a few hummocks or small dunes. Few areas of blown-out land are large enough to be delineated; small areas can be shown by spot symbols.

Cinder land is composed of loose cinders and other scoriaceous magmatic ejecta. Water-holding capacity is very low, and trafficability is poor.

Dumps are areas of smoothed or uneven accumulations or piles of waste rock and general refuse. *Dumps, mines*, consists of areas of waste rock from mines, quarries, and smelters. Some dumps with closely associated pits are mapped as "Dumps - Pits complex".

Dune land consists of sand in ridges and intervening troughs that shift with the wind. Sand dunes that have been stabilized by vegetation are named as a kind of soil rather than as "Dune land".

Glaciers are large masses of ice formed, at least in part, on land by the compaction and recrystallization of snow, moving slowly by creep down slope or outward in all directions due to the stress of its own weight, and surviving from year to year. A little earthy material may be on or in the ice.

Gullied land consists of areas where erosion has cut a network of V-shaped or U-shaped channels. The areas resemble miniature badlands. Small areas can be shown by spot symbols. Phases indicating the kind of material remaining may be useful in some places.

Gypsum land consists of exposures of nearly pure soft gypsum. The surface is generally very unstable and erodes easily. Trafficability is very poor. Areas of hard gypsum are mapped as *Rock outcrop.*

Lava flows are areas covered with lava. In most humid regions, the flows are of Holocene age, but in arid and very cold regions they may be older. Most flows have sharp, jagged surfaces, crevices, and angular blocks characteristic of lava. Others are relatively smooth and have a ropy glazed surface. A little earthy material may be in a few cracks and sheltered pockets, but the flows are virtually devoid of plants other than lichens.

Oil-waste land consists of areas where liquid oily wastes, principally saltwater and oil, have accumulated. It includes slush pits and adjacent areas affected by the liquid wastes. The land is barren, although some of it can be reclaimed at high cost.

Pits are open excavations from which soil and commonly underlying material have been removed, exposing either rock or other material. Kinds include *Pits, mine; Pits, gravel; Pits, quarry.* Pits are commonly closely associated with dumps.

Playas are barren flats in closed basins in arid regions. Many areas are subject to wind erosion and many are saline, sodic, or both. The water table may be near the surface at times.

Quarries (see *Pits*)

Riverwash is unstabilized sandy, silty, clayey, or gravelly sediment that is flooded and washed and reworked frequently by rivers.

Rock outcrop consists of exposures of bare bedrock other than lava flows and rock-lined pits. If needed, map units can be named according to the kind of rock: *Rock outcrop, chalk; Rock outcrop, limestone; Rock outcrop, gypsum.* Many rock outcrops are too small to be delineated as areas on soil maps but can be shown by spot symbols. Some areas are large, broken by only small spots of soil. Most rock outcrops are hard rock, but some are soft.

Rubble land consists of areas of stones and boulders. Rubble land is commonly at the base of mountains but some areas are deposits of cobbles, stones, and boulders left on mountainsides by glaciation or by periglacial processes.

Salt flats are undrained flats that have surface deposits of crystalline salt overlying stratified very strongly saline sediment. These areas are closed basins in arid regions. The water table may be near the surface at times.

Scoria land consists of areas of slaglike clinkers, burned shale, and fine-grained sandstone remaining after coal beds burn out. (Scoria land should not be confused with volcanic slag.)

Slickens are accumulations of fine-textured material, such as that separated in placer-mine and ore-mill operations. Slickens from ore mills consist largely of freshly ground rock that commonly has undergone chemical treatment during the milling process. Slickens are usually confined in specially constructed basins.

Slickspots are areas having a puddled or crusted, very smooth, nearly impervious surface. The underlying material is dense and massive. The material ranges from extremely acid to very strongly alkaline and from sand to clay.

Urban land is land mostly covered by streets, parking lots, buildings, and other structures of urban areas.

Water includes streams, lakes, ponds, and estuaries that in most years are covered with water at least during the period warm enough for plants to grow; many areas are covered throughout the year. Pits, blowouts, and playas that contain water most of the time are mapped as *Water*.

APPENDIX C

Script for
Guidelines for Using Soil Taxonomy in the Names of Soil Map Units
Slide Set

Prepared by

T. R. Forbes[1]
M. Tolomeo[1]

Department of Agronomy
New York State College of Agriculture and Life Sciences
Cornell University

with the help of

Media Services
New York State College of Agriculture and Life Sciences
Cornell University

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1. Senior Research Associate and Research Support Specialist, respectively, Department of Agronomy, New York State College of Agriculture and Life Sciences, Cornell University, Ithaca, N.Y. 14853.

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The soil is an important resource for human activity. Because the qualities of a soil often determine the success or failure of a development project, an effort is usually made to map the occurrences of different soil types.

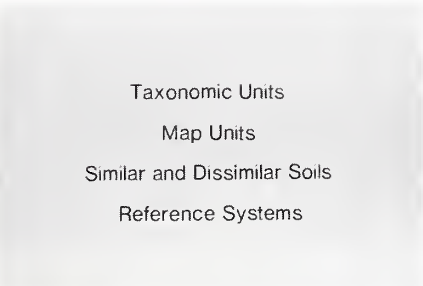
5
In developing countries, an important use of the soil map is to locate the best soils for agriculture.

Naming and grouping soils is a large part of making a map. For maximum effectiveness, soils should be named according to recognized guidelines.

6
This set of slides is an introduction to "Guidelines for Using *Soil Taxonomy* in the Names of Soil Map Units". The intent of the slide set is to *introduce major concepts*, and show how *Soil Taxonomy* and other reference systems are used to name map units. It is assumed that the map units to be recognized on the map have been determined and described but are not yet named.

Further information beyond that presented here can be found in the printed guidelines. As an aid in locating this information, references to the *Guidelines* are provided at the end of the slide set.

The slide set



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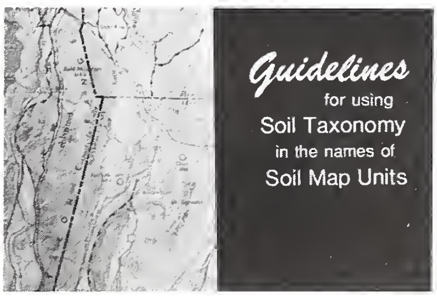
emphasizes concepts which are important to the understanding of: taxonomic units, map units, similar and dissimilar soils, reference systems, and other terms used in describing soil map legends.



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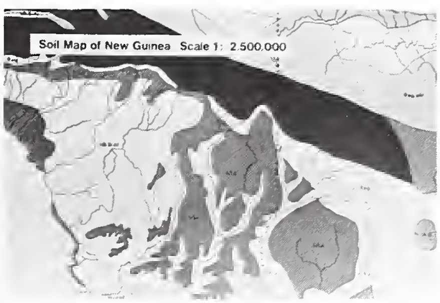

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As mentioned, the intent of this slide set is to show how *Soil Taxonomy* can help in naming map units and improve the information presented by the soil map. Before we proceed to this, some background information is necessary. The practical constraints of soil resource inventory work as well as the theoretical concepts of taxonomy should be understood. Let's address these in order.

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To create a soil map, accurate information is needed about what exists in the field. This information

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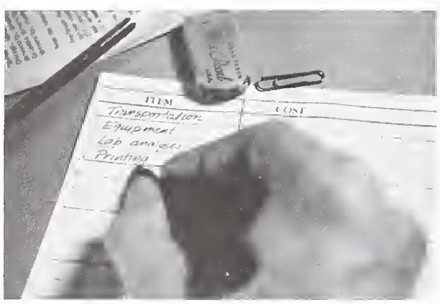
is collected by the soil surveyor. The surveyor's task is a large one that is accompanied by several practical constraints.

First,



12
making a soil resource inventory requires a substantial budget and effort. Each observation and sample represent

13
a specific amount of money from the budget and effort in the field, so it is often not possible to sample as much as one might like.

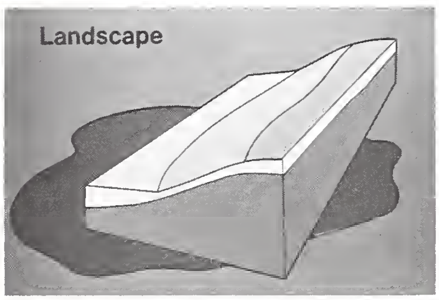
14
Second, soils may be so intimately intermingled in the field or occupy areas so small that they cannot be shown on a map at any practical scale.

Third,

15
the inaccessibility of certain areas because of transportation difficulties may restrict the number of sample points.

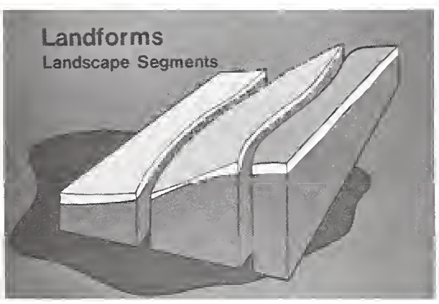
16
And last, it is not possible to follow the boundaries of a particular soil on the ground because all soils are hidden below the surface.

However, based on certain physical features in the landscape, a model can be developed to help with this constraint.



17
Soils are related to the landscapes upon which they are formed. If the surveyor can identify the different landscape segments, and associate the segments with certain soils, sampling and mapping then becomes a matter of verifying assumptions.

A landscape such as this one



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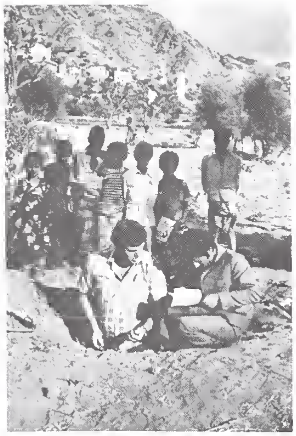
may be divided into 3 segments: valley, midslope and upland. The upland may contain soils with an ochric epipedon and an argillic horizon. The argillic horizon becomes less pronounced as one descends the midslope, and is replaced by a cambic horizon. The valley segment contains mottles and concretions with depth as a diagnostic feature.



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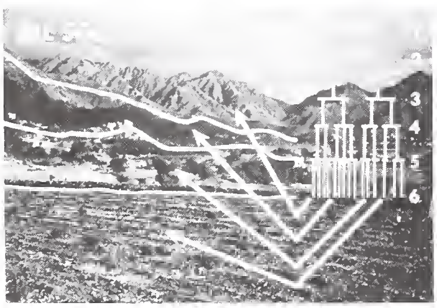
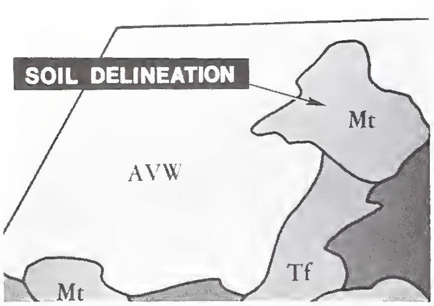
Although the soils found on a landscape segment will be related to that segment, each segment may still contain many different soils. The surveyor needs to select and describe soil profiles or pedons



20
and then classify the profiles according to *Soil Taxonomy.*

21
The map that results from the survey will contain a number of features.



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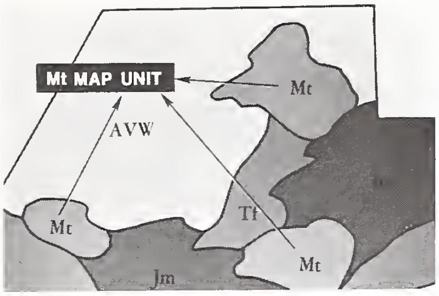
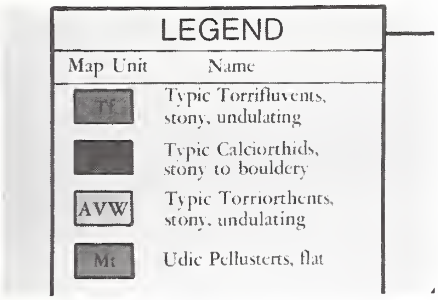
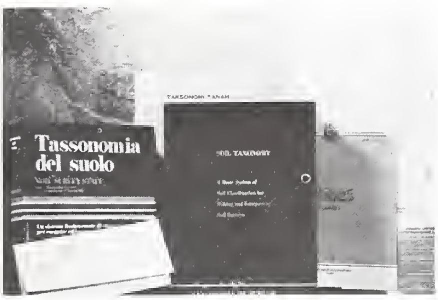
Soil boundaries are shown on maps by lines. The area enclosed by a soil boundary is called a *"soil delineation".*



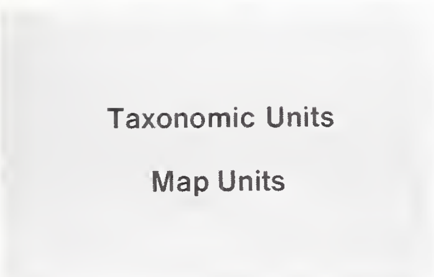
23
All soil delineations on a map which are identified by a unique symbol, color, or name join together to form a *"map unit"*.



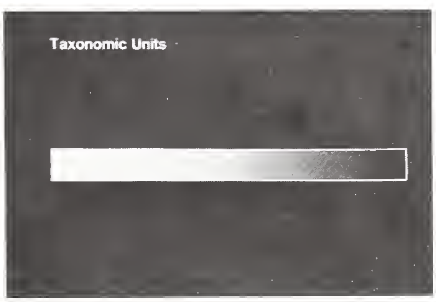
24
There are always several map units on one map. An organized list of map units showing map unit symbols, colors and names, is a *"map legend"*.



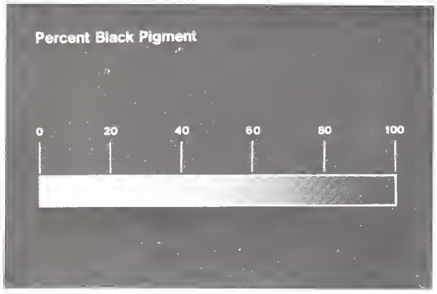
25
Map units have names. We will see how *Soil Taxonomy*, a soil classification system, can be used to provide names for map units and legends. But before discussing names, it is important to understand the difference



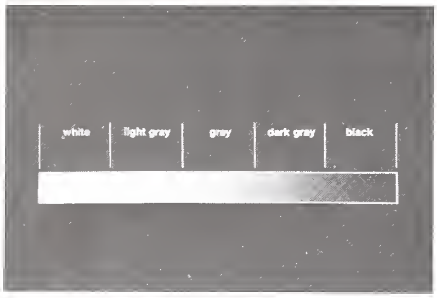
26
between taxonomic units and map units. The concept of taxonomic units might best be explained with an analogy.



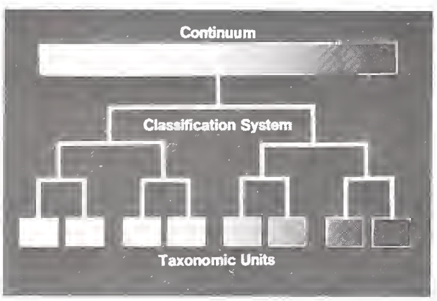
27
Imagine a scale that starts at white and ends at black with all shades of gray in between.



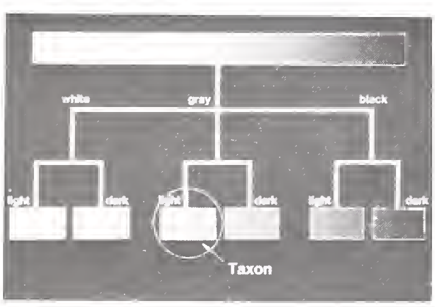
28
In order to be able to talk about specific shades on this scale, we arbitrarily divide it into five sections, and base the divisions on the amount of black pigment present. More divisions could be chosen which would make each class more precise in it's description. Since this is a continuum, each class will show some variation in the shade it defines. What we have done is to set limits for the class. As long as a shade falls within those limits, it is considered a member of the class.



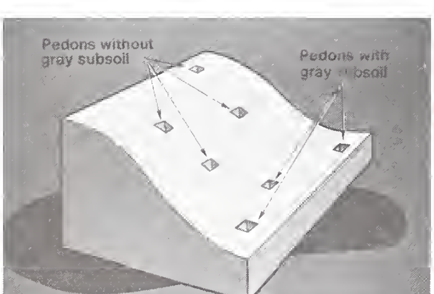
29
Names could then be given to the classes. With each of the names being well defined, the ambiguity about what is gray or white or black is removed. Remember that variation in each shade is permitted as long as it stays within the bounds of its class. Therefore, white is permitted to have up to 20% black in it because we have *defined* it that way.



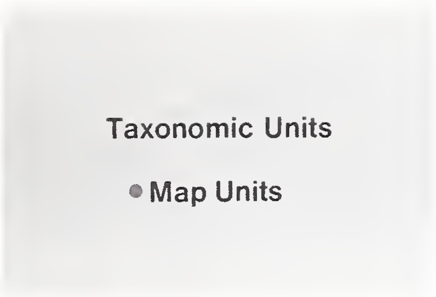
30
Soils that occur in the field also form a continuum. Diagnostic features will vary just as the amount of black pigment varied in the example. A taxonomic unit is an artificial division of the soil continuum that has been clearly defined. It is artificial because we set arbitrary limits for each class. Because of this, it does not actually exist on the landscape, but is used to sort the soils that are found on the landscape.



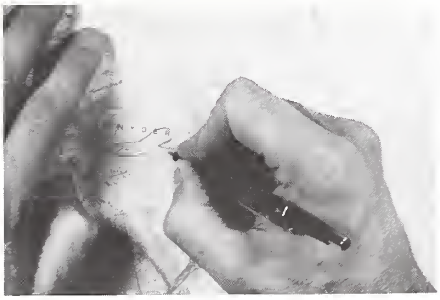
31
For example, it is possible to have a class which groups all soils having light gray colors in the subsoil. We can define what constitutes the shade 'light gray' and in a similar way define the area of the profile that is called the subsoil. The light gray color class in this case would be a taxon in a taxonomic system.



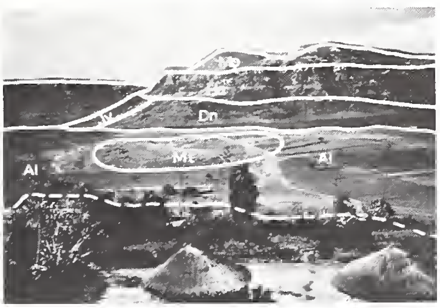
32
Any soil having the characteristic gray colored subsoil would be a member of this taxon. A standard has been established so that the gray taxon is the same no matter where one goes.



33
Now let's turn to map units. Several distinctions may be made between map units and taxonomic units.



34
Map units are not pure taxa. Whenever we outline a soil delineation on a map, it is almost certain that we are including soils from other taxa. A map unit may therefore contain a group of taxa.

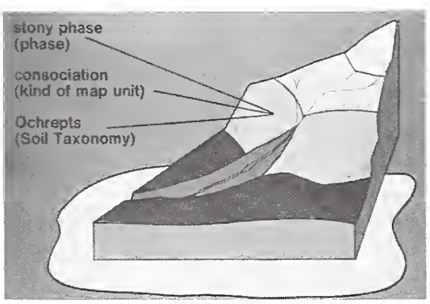


35
And, map units relate to actual segments of the landscape unlike taxa, which are conceptual classes.

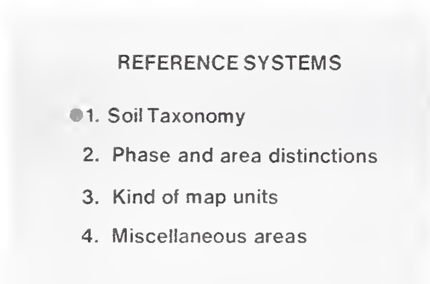
36
So, how *does* taxonomy relate to map units?

When combining the concepts of taxonomic units with map units, a taxonomic system is used as a reference to give names with consistent definitions. A name is only a label which refers to an address in the classification system. More than one reference system exists. For example, what do you call this object?

37
If your reference system was English, you'd call it a "glass". However, if your reference system was Spanish, it is "copa". It's the same object, but the name by which it's called varies.

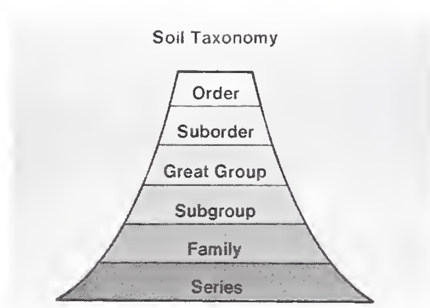


38
The same holds true for map units. One map unit may be called several names depending on which reference system is used. The map unit at the base of this hill could be called stony phase, a consociation, or Ochrepts. Let's look at four reference systems for soils:

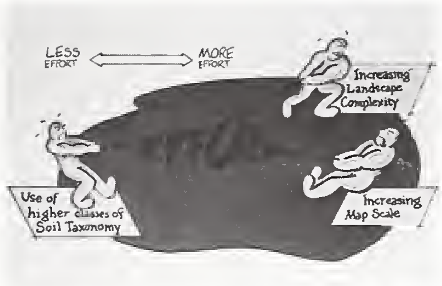


39
Soil Taxonomy, phase and area distinctions, kinds of map units and miscellaneous areas.

We've mentioned *Soil Taxonomy* - now let's look at it in more detail.



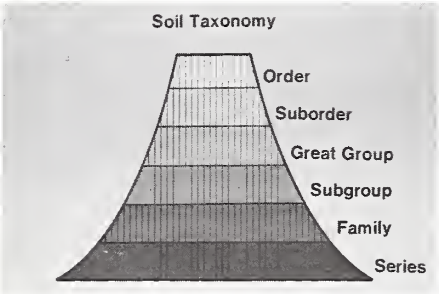
40
Soil Taxonomy is a reference system that creates divisions based upon the formative and diagnostic features of soils. The categorical levels used are: order, suborder, great group, subgroup, family and series. Orders are the coarsest level of classification having only 10 divisions. Series are the finest level with over 15,000 divisions recognized in the United States alone.



41
Using *Soil Taxonomy* to name map units can help with the constraints of map scale, landscape complexity and ultimately the soil resource inventory budget.

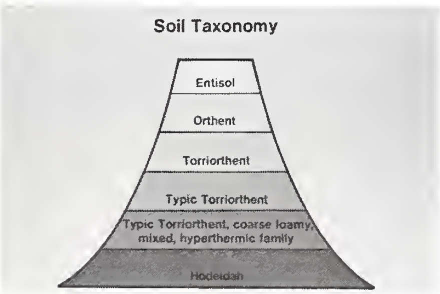
As landscape complexity or the map scale of the final survey report increases, more effort is required in the field.

The higher categories of *Soil Taxonomy*, which require less effort to map, can be used to offset this by concentrating on a limited number of important properties.



42
Soil Taxonomy is a dynamic classification system that is growing in size as unrecognized soils are described and added. Orders, Suborders and Great Groups are presently comprehensive. Any soil can be named using these categories. The Subgroup category is only partly comprehensive, and has gaps. Newly recognized soils may not fit into one of the existing Subgroups, and new Subgroups will have to be named. These gaps, which are a consequence of our limited knowledge of soils, sort of contaminate the families and series levels. These lower levels are therefore not comprehensive, and need constant attention of soil correlators to establish them. The series level is the most specific and has to be constantly expanded by the addition of newly described soils. This needs an active decision making process.

To illustrate the hierarchy of *Soil Taxonomy*, let's derive a series name for a particular soil.



43
At the order level it is an Entisol. The suborder is Orthent; the Great Group Torriorthent. Typic Torriorthent is the subgroup and the family name is: Typic Torriorthent, coarse loamy, mixed, hyperthermic family. The series name is Hodeidah.

So while the series name may not seem related to *Soil Taxonomy*, it is actually the finest division of its structured hierarchy.

44
Soil Taxonomy can be used at all categorical levels. However, the series level is the one most frequently used on large scale maps. Series are often named after localities. For the most efficient use, series names should be established

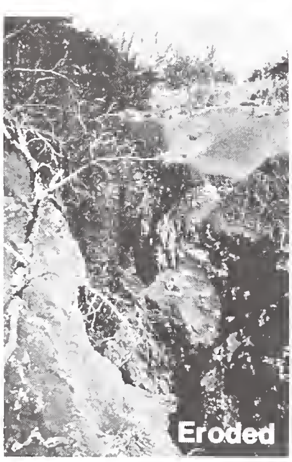
45
in a kind of a *Soil Taxonomy* national registry. Only when this correlation is accomplished, can these local names be used in a meaningful way.

REFERENCE SYSTEMS

1. Soil Taxonomy
2. Phase and area distinctions
3. Kind of map units
4. Miscellaneous areas

46
Phase and area distinctions form an additional reference base to describe map units. They supply information that is important for land use decisions and therefore, relate to the practical objectives of the map. A phase is a subdivision of a taxon while an area distinction is a subdivision of a whole map unit. Some examples of phases are

47
rolling: which limits cultivation and may make grazing a more suitable land use



48
eroded: where soil conservation practices are needed and agriculture is limited

Stony

49
and stony: again limiting to agriculture.

Phases are created to serve specific purposes of individual surveys. Therefore they do not form a taxonomy, as they can differ from map to map.

REFERENCE SYSTEMS

1. Soil Taxonomy
2. Phase and area distinctions
3. Kind of map units
4. Miscellaneous areas

50
Another system is the kinds of map units. The most important kinds of map unit are:

KINDS OF MAP UNITS

Consociation

Association/Complex

Undifferentiated Group

51
consociations, associations, complexes, and undifferentiated groups. These kinds of map units differ from each other in the number of taxa present and the percentage of the map unit that each taxon comprises. As mentioned before, a map unit usually consists of more than one taxon. Not all the taxa present will be used in the name. To understand the difference between the map units, how map units are named and what taxa are used in the name, we need to understand the concept of similar soils.

52
When grouping soils into map units we saw that no map unit will contain only one taxon. A certain amount of other soils will be present. Due to the constraints mentioned at the beginning of the slide set, the surveyor cannot possibly record all the soils in an area. However, if other soils are going to be present in the map unit, it would be best if they are similar to the soil or soils after which the map unit is named.

SIMILAR SOILS

Alike in most properties

Differences small in number and degree

Support similar land uses

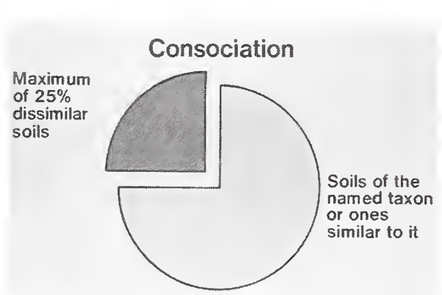
53
There are guidelines to help one decide if a soil is similar or dissimilar to another.

Similar soils are alike in most of their diagnostic properties. The differences that exist are minimal and small in degree as they relate to the same or similar land use.

54
For example, an Oxic Rhodustalf (which is an Alfisol) may be considered similar to

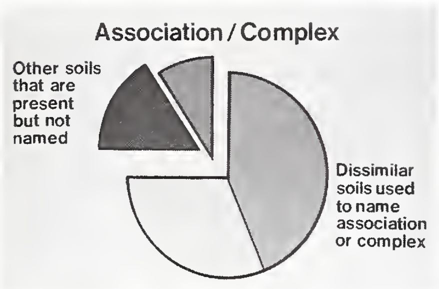
55
an Oxic Paleustult (which is an Ultisol). Although they belong to different orders, only the degree of base saturation separate these two soils.

56
With the idea of similar soils in mind, let's look at the definitions of the map units mentioned before.



57
Consociations are named for one taxon, but may contain more than that taxon. 75% or more of the soils in a consociation will belong to, or be *similar* to, the taxon for which it is named. The other 25% of the consociation may contain soils which are *dissimilar* to the taxon.

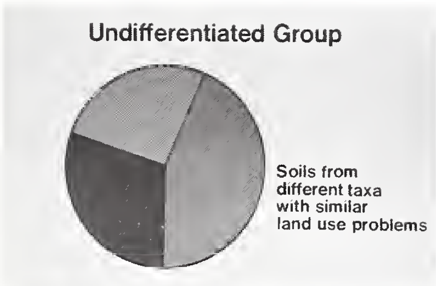
58
This series map uses consociations to represent the soils. Each delineation is largely composed of soils of the consociation name or ones similar to it.



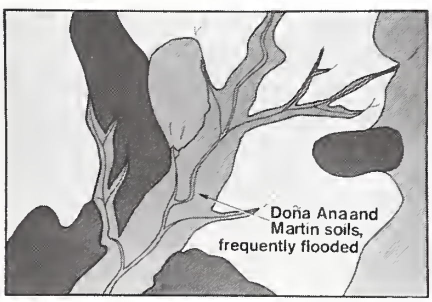
59
Another kind of map unit is the association or complex.

Complexes and associations usually contain two or three dissimilar soils. The name of the complex or association comes from the soils that account for 75% of the area in most delineations. The association differs from the complex in that the components of a complex cannot be separately mapped at a scale of 1:24,000.

60
When soils in the field are too small in area to be individually recognized at the scale of the map, an association or complex is used to characterize the delineation. This map is an overview to a detailed soil resource inventory presented as a general soil map. At 1:250,000, it uses 7 associations as map units. In the body of the survey, at a scale of 1:20,000, 39 map units were identified and named using much more refined taxonomic units.



61
Undifferentiated groups also consist of 2 or more taxa. The taxa are not associated in the field in any consistent manner, but are grouped together in the same map unit because use and management are the same or similar. Steepness, stoniness or flooding may be common factors used to group soils since these factors will limit land uses. One of these properties is so overwhelming that further distinctions add very little to the description.



62
As an example, the floodplain of the river (marked in blue) has been named using one map unit. It is reasonable to expect that dissimilar soils will be present along this 50 km stretch. The individual soils have not been mapped because they have one common limitation: they are frequently flooded.

63
In some countries, large areas are covered by non-soils. The final map needs to provide information on these areas and

REFERENCE SYSTEMS

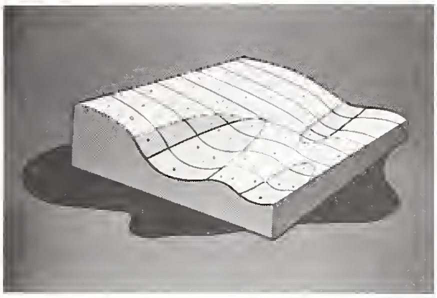
1. Soil Taxonomy
2. Phase and area distinctions
3. Kind of map units
4. Miscellaneous areas

64
a reference system for miscellaneous areas is used. Such areas include (but are not limited to):

65
rock outcrops

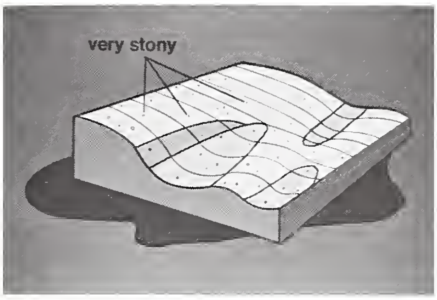
66
urban areas

67
or water.

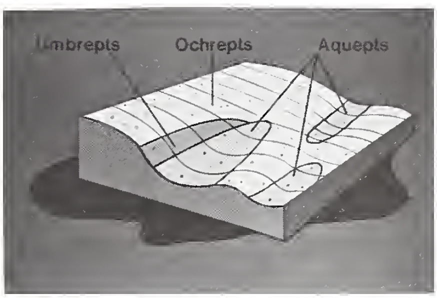


68
The name of the map unit will depend on factors such as the map scale, the complexity of the soils in the field and the information that is available from the survey. The objective in naming a map unit should be to provide information in a clear and concise manner. Let's examine some of the concerns that might arise in attempting to do this.

Suppose we were to describe this landscape. Three reference systems could be used.



69
The phase distinction would be "very stony".

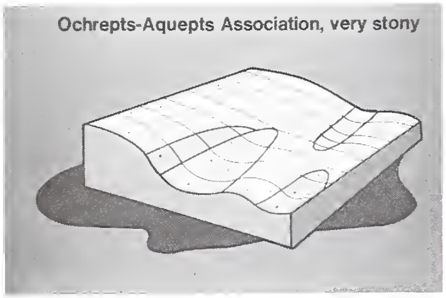


70
Soil Taxonomy is used for the suborder names of Ochrepts, Aquepts and Umbrepts.

At a large scale such as this, consociations could be used for the kind of map unit. Three map units would be present: a consociation of Ochrepts, a consociation of Umbrepts and a consociation of Aquepts.

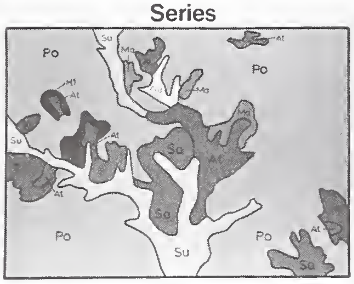
If we reduced the scale of the map so that the block diagram looked like this

71
we might want to change the map unit. Less detail can be shown at this reduced scale, so consociations, in this case, would be hard to represent. Since dissimilar soils make up at least 75% of the delineation, we would consider an association or complex for the kind of map unit. An association would be chosen over the complex because it is possible to separate the components at the larger scale of 1:24,000.



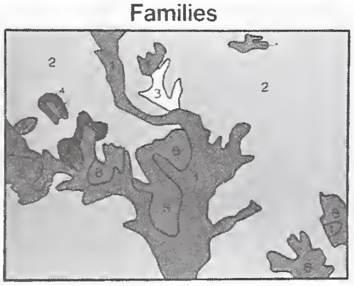
72
Since Umbrepts account for less than 10% of the area in this delineation, they would not be used in the name of the map unit. Instead, we'd call it an Ochrepts-Aquepts Association, or more precisely, Ochrepts-Aquepts Association, very stony.

Series



73
When using the coarser levels of *Soil Taxonomy*, it is important that small areas that can influence land use decisions are not overlooked. This detailed map shows map unit delineations named as soil series at a scale of 1:20,000. The delineations marked with an "At" are a soil that has serious limitations for agricultural production.

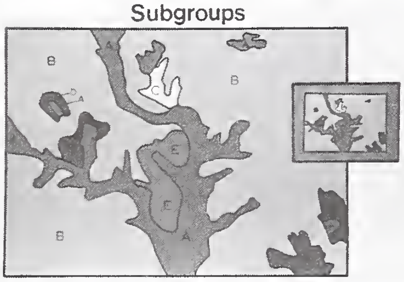
Families



74
At the family level and same map scale, the number of delineations has decreased, since different series can belong to the same family. The At series is now contained in the family marked with a "1", and cannot be separated out without using series map units.

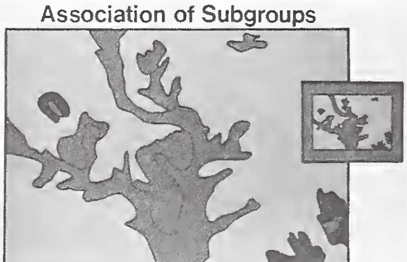
Some information has been lost using this level instead of series. We know that the At series can be present, since it is a member of the family, but do not know its exact location. The trade-off is, this map requires less sampling and effort in the field to produce.

Subgroups

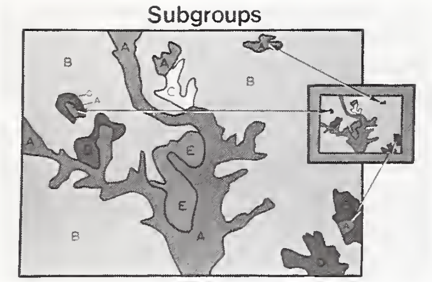


75
On regional maps, coarser categories of *Soil Taxonomy* are often used along with smaller scales. If this map were reduced to 1:86,000, as it is in the inset, problems with legibility start to arise. The consociations in the center might be grouped

Association of Subgroups

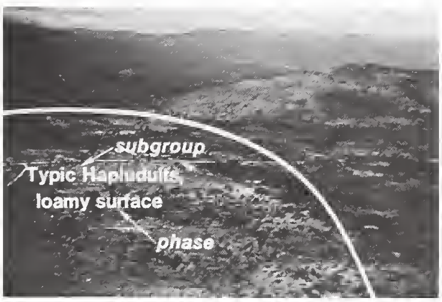


76
into an association to help legibility. Larger consociations, such as the orange area would still be visible and would not need to be combined.

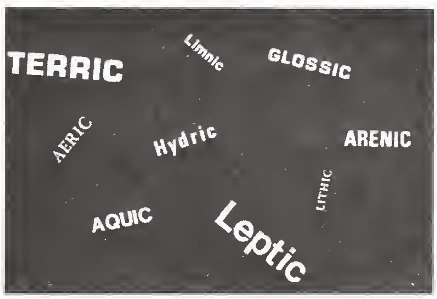


77
Another legibility problem has to do with the small areas (in red) of the soil that are of consequence to agriculture. The area they occupy is too small to affect the map unit chosen; area B would still be a consociation. But, they are too small to represent as an individual consociation. As a result, they probably would not be included on the final map. In the Soil Survey Report a description of the consociation in which they occur should alert the map user to the possibility of their presence.

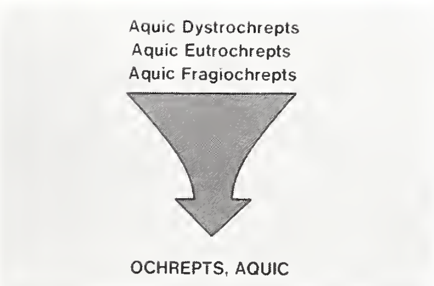
78
On detailed maps, consociation names often include the phase of the soil series. "Santa Barbara silt loam, 3-8% slopes, eroded", is an example of such a map unit.



79
However, phases can also be used with other categories, such as subgroups. Although this too is a phase of a consociation, it may have a greater diversity of soils than found at the series level.



80
Other terms from *Soil Taxonomy*, besides those of taxa, can be used to qualify whole areas of a survey. Certain soils aggregate in parts of landscapes where they may share diagnostic horizons recognized by *Soil Taxonomy*.



81
For example, suppose these Ochrepts - Aquic Dystrochrepts, Aquic Eutrochrepts and Aquic Fragiochrepts - are found in a valley. The valley could then be characterized by a map unit named "Ochrepts, aquic", which implies the soils are wetter than the "typic".

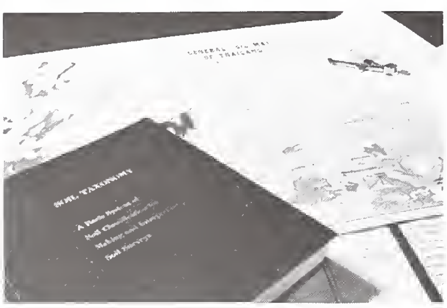
82

83

The soil map is a useful planning tool although it can only approximate the conditions that exist in the field. Due to the manner in which soils may occur, and the physical and budgetary constraints upon the surveyor, it is not possible to duplicate the "ground truth" on a map.

In order to convey the most information to the user of the survey, the names for map units must be carefully chosen. Reference systems can help with choosing names. We briefly discussed four such systems: *Soil Taxonomy*, phase and area distinctions, kinds of map units and miscellaneous areas.

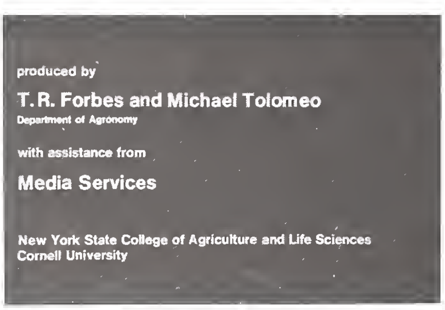
84



Soil Taxonomy is the preferred system to classify soil profiles and designate components of map units for a number of reasons. The categorical level for mapping can be chosen to fit the landscape complexity, map scale, available budget, time and effort.

Soil Taxonomy is a rigorous reference system that can be used in a flexible way. It can be used with other reference systems to name soils and map units in a consistent and accurate fashion, which will enhance the effective use of the soil map. Planning decisions can then be made with a greater degree of confidence.

85



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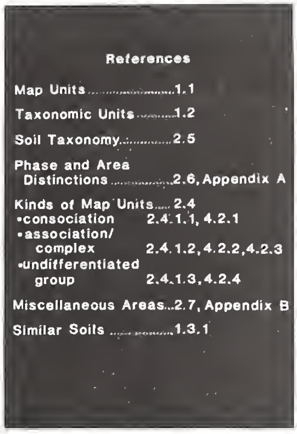

87
As we mentioned in the introduction, this slide set is an overview and is meant to introduce the printed guidelines. More information on the topics covered can be found in the guidelines at the following locations.

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